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POSTANESTHETIC ENCEPHALOPATHY FOLLOWING CYCLOPROPANE

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THE purpose of this paper is to place on record the report of an instance of degenerative changes in the brain following cyclopropane anesthesia. The clinical course and the cellular changes found at postmortem substantiate the diagnosis of postanesthetic encephalopathy. The former was singularly similar to cases reported following nitrous oxide anesthesia,[1, 2, 3] while the latter were identical to the changes observed in three other cases[4] in which cyclopropane was not the anesthetic agent employed. A survey of the literature has not disclosed a similar, previous report, or any reference to brain damage resulting from the use of cyclopropane.

Case Report.—F. L., white, female, age 29, was admitted to the Lowman Memorial Pavilion of the Cleveland City Hospital, May 18, 1937, with a four-year history of pulmonary tuberculosis. A right phrenic nerve crush, performed one year previously, had failed to arrest the progress of cavitation in the right apex.

Physical Examination revealed râles in the right upper chest, mild tuberculous laryngitis, lively tendon reflexes, but was otherwise negative. Blood pressure 130/80. Pulse and temperature normal. Vital capacity 53 per cent. Serial roentgenograms indicated gradual progression of a tuberculous process in the right apex to the formation of an area of multiple cavitation measuring 7.5 by 4.5 cm., scattered subapical infiltration on the left, a right cervical rib, and a mobile diaphragm. Uranalysis, negative; blood Wassermann, negative; red blood cells, 4,800,000; hemoglobin, 80 per cent.

The patient expectorated 4 to 6 Gm. of mucopurulent sputum daily, which contained acid-fast Bacilli. Pneumathorax was induced on the right, but was discontinued because of a contraselective collapse.

Operation.—July 28, 1937: A right, first-stage thoracoplasty was performed by Dr. S. O. Freedlander. The first two ribs were completely resected as was a major portion of the third and the cervical rib. The latter procedure was time consuming, but necessary because it prevented collapse in the apicocaudal diameter. The intercostal musculoneurovascular bundles were removed and an apicolysis performed. The second and third transverse processes were resected. Preoperative medication consisted of sodium amytal grains iii, two hours previously, morphine sulphate grains ¼, and atropine sulphate grains 1/150. The operation was performed under cyclopropane anesthesia administered by the carbon dioxide absorption technic.[5] Before induction the blood pressure was 110/70, pulse 80, and respirations 20. Throughout the procedure the skin was

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warm and pink, the respirations were 24, and the pulse varied between 70 and 80 until completion when it rose rather rapidly to 145. After induction the blood pressure increased to 120/80 and remained there until the pulse started to become more rapid when the pressure dropped to 90/60. The anesthetist recorded the postoperative condition as "good." A venoclysis of 5 per cent glucose in distilled water was started. The anesthesia lasted two hours and 35 minutes, the operation two hours and 15 minutes.

On the patient's return to the ward the blood pressure was 84/55 and the skin color was noted as "poor." Ephedrine, grains ¾, was administered. Fifty minutes later the blood pressure was 90/60, pulse 120, and respirations 36. Oxygen per nasal catheter was started because of cyanosis; the patient was semiconscious; the pulse was regular and of good volume. Less than two hours after the completion of the operation the blood pressure was 115/60, the pulse 108, respirations 36. The patient remained stuporous until four hours after operation when she complained of pain and morphine sulphate, grains 1/6, was administered. The venoclysis was discontinued after 12 hours, 3400 cc. having been given; the cyanosis cleared, the blood pressure remained at about 118/60. The patient rested well. There was some frequency and difficulty in voiding.

Postoperative Course.—The day following operation the patient's general condition seemed good; oral fluids were retained. There ensued a gradual rise in temperature and pulse, until 24 hours postoperatively when emesis occurred. At this time the temperature was 39.2° C., pulse 140, and respirations 24. After gastric lavage, catheterization, and the initiation of venoclysis, the patient appeared comfortable and her condition was satisfactory. Thirty-six hours following operation she had a mild convulsion and became comatose. Pulse good; respirations groaning, deep and irregular; blood pressure 132/64. No response could be elicited. Shortly afterward her general condition became critical, the pulse became thready, and cyanosis ensued in spite of oxygen which had been continuously supplied. Intravenous fluid and coramine were given as well as 500 cc. of citrated blood. Ten hours after the convulsion there was an apparent improvement; the skin became pink; the pulse was strong and regular but varied in rate from 80 to 150; the blood pressure remained normal.

The patient never regained consciousness; at times she appeared attentive and responded with a glance; but never spoke, and made purposeless movements especially with the left arm and hand. A complete neurologic examination gave no definite objective findings. Slight icterus and hemoglobinuria followed the blood transfusion. The temperature remained around 39° C., and the respirations around 40. Repeated uranalysis disclosed a trace of albumin and benzidine four plus, but gross hematuria did not recur. Seventy-two hours following operation the spinal fluid pressure was 16 Mm. of mercury. The fluid contained no cells and the Pandy test was negative. Five days after operation the findings remained the same, with a spinal fluid pressure of 18 Mm. of mercury, and a flat gum-mastic curve. The white blood count on the third day was 23,000, with 90 per cent polymorphonuclears. A second blood transfusion was given on the third postoperative day.

The patient was in deep coma and had involuntary urine and feces. Neurologic examination and examination of the eye grounds furnished no evidence of localized brain damage. The picture was one of decortication, and signs of meningeal irritation developed on the fifth day in the form of nuchal rigidity. There were irregularly occurring periods of low blood pressure; thready, rapid pulse, and Cheyne-Stokes respiration. On the sixth day facial grimaces were noted and the abdominal reflexes could not be elicited. On the following day repeated generalized convulsions occurred with marked opisthotnos, and the patient died seven days and six hours following operation.

During the postoperative period intensive supportive treatment maintained the patient's intake and output within normal limits. Blood studies revealed a reduction in the whole blood chlorides but nothing else of significance.

Autopsy performed by Dr. Robert P. Hill revealed:

(1) Chronic ulcerative pulmonary tuberculosis, bilateral, with cavitation of the right apex.
(2) Subacute pulmonary tuberculosis, bilateral.
(3) Acute ulceration of the mucosa of the urinary bladder.
(4) Acute hemorrhagic erosions of the gastric mucosa.
(5) Passive hyperemia of the kidneys.

Pathologic Examination.—Grossly the brain was negative as were hemotoxylin and eosin sections. Dr. Albert T. Steegmann, who will include this case in a series in a future publication, reports the following histologic examination:

"Representative areas of the brain were embedded in nitrocellulose and stained by the Nissl method. The glial cells were stained by Stern's modification of the Hortega stain for celloidin-embedded material.

"The leptomeninges show some thickening and proliferation of fibroblasts. There is a light infiltration of round cells, mononuclear cells, pigment filled phagocytes, and red blood cells. The subpial vessels are occasionally surrounded by collars of round cells.

"There is a severe degenerative process involving the ganglion cells of the entire cerebral cortex, with a loss of ganglion cells sometimes producing diffuse cell defects and again cell defects of an irregular patchy distribution. The most severe disease was found in the temporal lobes and hippocampal gyri, but the frontal and central areas were also severely involved. The process was of less severity in the parietal and occipital regions. There was a great variation in the involvement of the cortical cellular layers. In some regions only lamina II was preserved. In other areas the greatest cell defects were seen in lamina III, IV and V. This variation was so changeable in different sections, and in different areas of the same section, that no areas of consistent predilection could be defined.

"The cell defect in Sommer's sector of Ammon's horn was a significant change, because of the established evidence that this area is particularly vulnerable to ischemic damage (Spielmeyer and his school). The cells of the globus pallidum were similarly damaged; the neostriatum, thalamus, brain stem and cerebellum were all spared and showed no significant changes.

"The type of ganglion cell disease was of several varieties. The most common type was the severe cell disease (Nissl). In many areas of the cortex and especially in Ammon's horn and the globus pallidum it was of the homogeneous-ischemic, or ischemic type. Cell degeneration by shrinkage or by swelling and dissolution was not infrequent. In the areas of degeneration there was a pronounced activity on the part of the neuroglia especially the microglia. The formation of rod cells and compound granular phagocytes from the microglia could be traced in various stages of evolution. There was also a proliferation of the capillaries and small blood vessels in the zones of severe damage.

"There is a remarkable resemblance of these changes to those seen in the brain damaged by ischemia from vascular occulsion which leaves little doubt that the encephalopathy described (which is a purely degenerative process) is of anoxemic origin."

DISCUSSION.—The exact mechanism or biochemorphology[6] of deep sedation and anesthesia is not known; perhaps it is localized anoxia secondary to vasomotor disturbance; perhaps some biochemical change alters tissue respiration; perhaps it is a selective suspension of function by other means, that is, a specific narcotic action. There seems to be good evidence that the narcotic action of nitrous oxide is enhanced by some degree of anoxemia. It must be given in high concentration, and its administration is frequently

accompanied by clinical cyanosis. Cyclopropane, on the other hand, is given in low concentration and usually accompanied by "good color." The clinical evidence of tissue anoxia is lacking. However, "cyanosis and anoxemia are not synonyms and do not necessarily accompany each other."[1] Consequently, the above case has been presented in considerable detail, for it is deemed important to study the events during anesthesia and those culminating in clinical evidence of brain damage. The patient was better than the average risk and the operation was somewhat unusual because of its duration, but otherwise there was no untoward incident to cause alarm.

It is possible that cerebral anoxia or a localized anoxemia can occur in a brain without objective manifestations; such as changes in blood pressure, color, pulse, or respiration, especially if the function of that organ is partly and temporarily abolished by anesthesia. Obviously, that is beyond our scope. However, we can say that no general cyanosis occurred during anesthesia and that for a short period immediately after the operation there was cyanosis and stupor with rapid respiration. These were not notably unusual and were soon followed by recovery. We do not believe that during this period there was clinical evidence of a general anoxemia severe enough, or of enough duration, to produce a localized degeneration of the brain. We do admit that a localized anoxia may have occurred here, or even during the anesthesia, without clinical evidence of its presence.

Postanesthetic encephalopathy is a definite clinical entity. If further studies prove it to be a pathologic entity, we are led to suspect a similar pathogenesis whether the causative agent be nitrous oxide,[1, 2, 3, 4] avertin, morphine and its derivatives,[3] or cyclopropane. In regard to cyclopropane we are confronted with the following possibilities: First, it has a specific narcotic action which is uninfluenced by anoxia or anoxemia, and which may produce the above described changes in the brain; second, it does not produce degenerative changes, and these changes in this case were secondary to a short period of cyanosis postoperatively; third, like nitrous oxide the mechanism of its effect, both in the production of anesthesia and brain degeneration, depends in part on anoxemia, but unlike nitrous oxide the anoxemia is localized and clinical cyanosis is lacking; finally, it is possible that any drug, which will temporarily suspend the function of a portion of the brain, will under given circumstances, such as of dosage, of individual dyscrasia, or of physiologic state, produce certain degenerative changes in that portion. If these changes are the same for a given group of drugs, it is likely that the mechanism of their production is the same.

Herein lies the problem of the pathogenesis of postanesthetic encephalopathy: Is it a process of anoxemia or a specific toxic effect? Is it related to cellular respiration? Is it independent of the biochemorphology of a given drug, or an exaggeration of its usual narcotic action? Further study of more cases and investigation of the alterations of cellular physiology induced by anesthetics may lead to a definite conclusion regarding the pathogenesis. At present we can only theorize with the material available.

Of the possibilities enumerated above, the first we regard skeptically, because of the nature of the cerebral degeneration. The second possibility we disfavor after recapitulation of this case and the study of others. The third possibility, that of tissue or cellular anoxemia, we believe carries the bulk of supportive evidence. Those cases reported[1, 2, 3, 4] in which there has been a careful postmortem examination of the brain present almost identical histologic changes—all degenerative, unlike the changes of "toxemias" such as of pregnancy and mushroom poisoning, but similar to the changes produced by poisoning with narcotic drugs like morphine. We believe death is due to this cortical destruction and we know that the same changes can be produced by ischemia and vascular occlusion. The histologic picture is rather constant and typical, and the localization of the degeneration follows the vulnerability of the tissues to anoxemia as well as occurring in that portion of the brain usually affected by anesthetic drugs.

Those cases of death following anesthesia of very short duration[3] may not be cortical deaths. Histologic evidence of damage cannot be expected to occur instantly. On the other hand, proper brain studies were not made in the cases with survival periods under 24 hours. Respiratory failure, a rather common occurrence in this condition, may contribute generously to the degeneration though it endure minutes only, and the anesthetic not much longer.

Gianotti's[7] observation suggests a vasomotor mechanism in the anesthetic action of nitrous oxide. The fact that it is the most common offender in the production of postanesthetic encephalopathy and that it must be administered in high concentration at the expense of oxygen inclines one to favor the anoxic theory. Finally, in the last analysis many so-called "specific, toxic and poisonous" effects operate in the brain and other organs through the production of cellular asphyxia.

REFERENCES

[1] Courville, C. B.: Asphyxia Following Nitrous Oxide Anesthesia. Medicine, **15**, 129, 1936.

[2] Courville, C. B.: The Pathologenesis of Necrosis of the Cerebral Gray Matter Following Nitrous Oxide Anesthesia. Annals of Surgery, **107**, 371–379, March, 1938.

[3] Lowenberg, K., Waggoner, R., and Zbinden, Th.: Destruction of Cerebral Cortex Following Nitrous Oxide-Oxygen Anesthesia. Annals of Surgery, **104**, 801, November, 1936.

[4] O'Brien, J. D., and Steegmann, A. T.: Severe Degeneration of the Brain Following Nitrous Oxide-Oxygen Anesthesia. Annals of Surgery, **107**, 486–491, April, 1938.

[5] Waters, R. M.: Carbon Dioxid Absorption from Anesthetic Mixtures. Calif. and West. Med., **35**, 342, November, 1931.

[6] Leake, C. D.: The Rôle of Pharmacology in the Development of Ideal Anesthesia. J.A.M.A., **102**, 1, January 6, 1934.

[7] Gianotti, M., and Vannotti, A.: Capilloroskopische Untersuchungen wahrend der Narkose. Zeitsch. fur die Gesamte Experim. Mediz., **82**, 240, 1932.

SEVERE DEGENERATION OF THE BRAIN FOLLOWING NITROUS OXIDE-OXYGEN ANESTHESIA

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THE severity of the changes in the brain consequent to the encephalopathy following nitrous oxide-oxygen anesthesia have been described by Lowenberg, Waggoner and Zbinden,[1] and by Courville.[2, 3] The purpose of this report is to describe the clinical course and changes in the brain of a patient who lived much longer than the other cases which have been reported.

Case Report.—J. F., white, female, age 31, entered St. Johns Hospital on the service of Dr. C. E. Steyer, August 19, 1933, for the purpose of a cystoscopic examination and removal of a small papilloma of the bladder. Otherwise she was mentally normal and in a state of good physical health. The operation, which was performed under nitrous oxide-oxygen anesthesia, lasted 37 minutes. No note was made of any circulatory or respiratory arrest occurring during the anesthesia and the patient was thought to be in good condition until unconsciousness following the anesthetic was noted to be excessively prolonged. After eight or nine hours in an unconscious state the patient became extremely restless, which progressed to a state of screaming, maniacal behavior. The following notes summarize the essential clinical observations made over a period of 16 months, until the time of the patient's death.

Postoperative Course.—The day following the operation coma persisted, being interrupted with screaming, tossing about and generalized convulsions at intervals. During the remainder of the patient's life there was never a return to a conscious type of mental activity. The patient had to be restrained; involuntary urination and defecation occurred.

Five days later there was twitching of the facial muscles, more pronounced on the left side. The left pupil was dilated; the patient exhibited difficulty in swallowing and generalized twitching of the musculature of a semiconvulsive type.

Thirty days later the patient began to moan loudly and was extremely restless following pressure on any part of the body. Generalized convulsive movements occurred at times and fine fibrillary twitching was noted throughout the body. The extremities were held in a state of rigidity; at times she would spontaneously utter sounds similar to those made in "jargon" aphasia. There was a bilateral foot drop. The tendon reflexes were hyperactive on the left side where an abortive clonus and a positive Babinski sign could be elicited.

Nine weeks after the operation she cried, whined, ground her teeth and screamed loudly. She seemed hypersensitive to noise. Decubitus ulcers developed over both lips.

Five months after the operation the patient was transferred to the Mercy Hospital, Canton, Ohio, to the care of Dr. John D. O'Brien. The crying and moaning continued

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and the patient presented a picture of decerebrate rigidity with the head hyperextended and turned to the left, the left arm and leg spastic and visibly atrophic. The right leg was also atrophic. Facial grimacing and marked difficulty in swallowing were observed. There was no sign of cooperation but at times the patient would apparently follow with her eyes the movement of a person in the room. From the beginning of the illness a high temperature, reaching at times 106° F. and rapid, shallow respirations had been present. The temperature ranged between 102° to 106° F. on the average, for periods of a week at a time and would subside and recur at irregular intervals. The appearance of the skin was not remarkable.

A year after the operation she developed a phlebitis in the left thigh accompanied by profuse diaphoresis and a temperature of 106° F. for a few days. This was followed by bloody stools which recurred from time to time during which a cast of the bowel would be passed. During this period the decerebrate posture resembled the position of a running gait with the head thrown back, the arms semiflexed, the hands clinched, and the legs flexed in the running position. This posture was maintained with little change until the time of death.

Only one fact of significance was revealed in the past history. Three years before the present illness the patient had been given a nitrous oxide anesthetic for the extraction of a tooth. She took the anesthetic so poorly that it was necessary to switch to ether anesthesia. Afterwards she remained unconscious much longer than usual but upon regaining consciousness was apparently perfectly normal.

The patient died suddenly December 17, 1936, 16 months after the operation.

Laboratory Data.—The spinal fluid examined immediately after the operation showed a pressure of 250 Mm. of water, contained two mononuclear cells per cmm., and showed a trace of globulin. Subsequently, during the life of the patient, about 20 spinal fluid examinations were made at frequent intervals without revealing any other abnormality. The blood picture was not unusual except for a leukocytosis which averaged about 15,000 white blood cells per cmm. At times pus cells appeared in the urine but not persistently.

Pathologic Examination.—Gross: The autopsy was limited to examination of the brain, which was removed two and one-half hours after death. The dura was adherent to the calvarium over the vertex. Considerable clear spinal fluid escaped on opening the dura which was thickened. Beneath the dura, and loosely attached to it, there was a smooth, gray to reddish-brown colored membrane which measured about 1 Mm. in thickness. This covered all of the dura removed including the falx cerebri. The membrane was thickest over the centroparietal regions, especially on the left side. The brain weighed only 900 Gm. after fixation in 10 per cent. formalin. The leptomeninges were thin and transparent. The basilar and cortical blood vessels were thin-walled and collapsed at the base but were hyperemic over the central and parietal cortex and along the sylvian fissure, especially on the left side. The convolutions were flattened, with shallow sulci, and were quite soft to palpation from the central region backward to both occipital poles. Coronal sections of the brain revealed moderate generalized ventricular dilatation and bilateral degeneration of the caudate nucleus, the putamen and the white matter of the parietal and occipital regions. In its superior aspect the gray matter of the cortex was thin and showed a yellow discoloration of the intermediate zone in a large part of many convolutions. All of the cortex was granular and discolored in the occipital region where the degeneration was most severe, decreasing in degree towards the frontal region. The neostriatum (caudate nucleus and putamen) on both sides was soft, shrunken and granular to spongy in appearance. The degenerated tissue was patchy in distribution and of a rust-brown color. The globus pallidum was yellow in color, slightly shrunken but not degenerated. The degeneration in the white matter began in the vertex of the left central region to involve both parietal areas, becoming more extensive in the occipital poles (Fig. 1). The degenerated white matter was soft, granular to mealy in appearance, and yellowish-gray in color. The corpus callosum was thin. The brain stem and cerebellum exhibited no gross changes.

Histologic Examination.—Frozen sections and sections embedded in nitrocellulose were stained by special neurohistologic methods for the various tissue elements.

The subdural membrane consists of an old organized subdural hemorrhage containing dense collagenous connective tissue. In areas where the structure is of a looser character, mononuclear phagocytes, some of which contain iron and blood pigment, are present. Venous spaces in areas had ruptured, releasing red blood cells into the tissues.

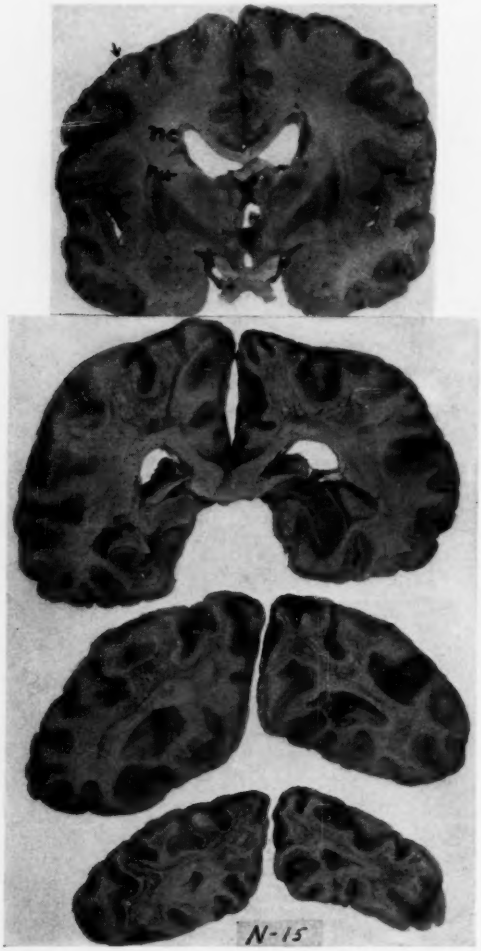

FIG. 1.—Photographs of coronal sections through the brain to demonstrate the degeneration of the cortex (arrow), the nucleus caudatus (n.c.), the putamen (Put) and the white matter of the parieto-occipital region. Occipital pole below.

The leptomeninges are moderately thickened and infiltrated with mononuclear cells, round cells and in places red blood cells. The pial vessels are dilated.

The degenerative changes in the cerebral cortex are more extensive than could be detected grossly. The degeneration involves the different layers of the cortex to a variable degree in different regions. The third and part of the fourth cortical layers are in general the most selectively damaged and present a pseudolaminar degeneration of a striking character. In many regions (*i.e.*, occipital) all of the layers are degenerated, in places only the second layer is spared. In other areas other combinations of degeneration occur and several of these variations may be present in a single section taken from a given region. In these regions the ganglion cells have completely disappeared or the diseased cells remaining are undergoing degeneration by shrinkage, by the ischemic type of cell disease or by dissolution from swelling and disintegration. A spongy state of the tissues remains as the result of this process. The pericellular spaces of the diseased ganglion cells are greatly widened. The large pyramidal cells in the fifth cortical layer in some areas are calcified. In other areas they are undergoing the axonal reaction possibly as a result of the destruction of the white matter lying below (Fig. 2). In the areas of cellular destruction there is a secondary reaction of the mesodermal tissue with the formation of fibroblastic strands and the proliferation of new capillaries which stain well with the tannin-silver method of Achucarro. Much fat is also found in these areas either lying free in the tissues or in compound, granular phagocytes which are very numerous in some areas. The reaction of the neuroglia is less pronounced, but large astrocytes are found above and below the areas of severe destruction. The microglia shows swollen retracted processes in silver stains. The degenerated white matter shows a loss of axis cylinders, demyelinization, compound granular phagocytic cells, protoplasmic astrocytes and a general increase of the

glia cells with irregular (anisomorphous) fiber gliosis. The same type of degeneration described above in the cortex is present in the caudate nucleus and putamen on each side. There are no inflammatory changes or evidence of primary disease of the blood vessels.

Regions of the brain other than those described are not degenerated. There is a bilateral, secondary, partial degeneration of the pyramidal tracts.

DISCUSSION.—Fatalities occurring during, or immediately after, nitrous oxide-oxygen anesthesia may, or may not, be due to the action of the anesthetic on the central nervous system. When death occurs after an interval of

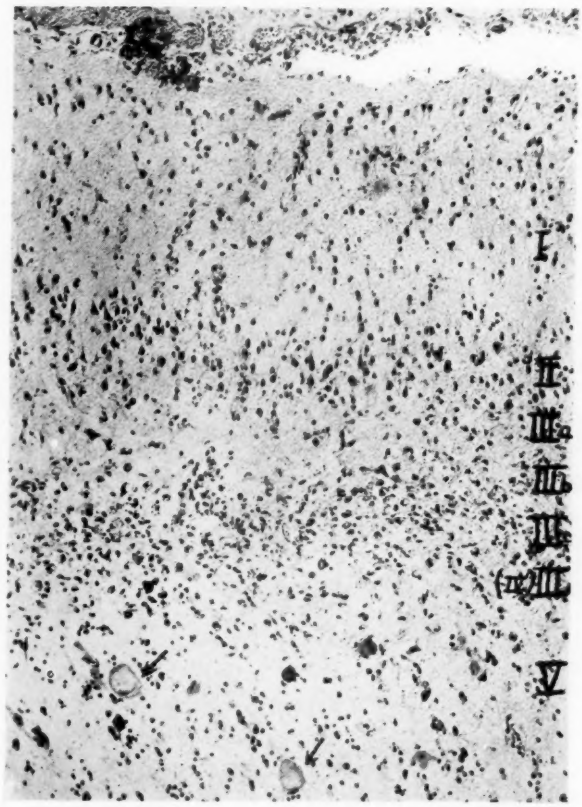

FIG. 2.—Photomicrograph of the motor cortex, demonstrating the cellular defect in laminae III and IV. This region contains connective tissue, capillary sprouts, débris and compound granular phagocytes. In lamina V, Betz cells are seen undergoing axonal degeneration (arrows). Nissl stain (× 130).

hours, days or weeks, the origin is almost always a damage to the central nervous system. This case is an example of death resulting from extensive damage to the central nervous system in which the primary lesion was compatible with life for the unusually long period of 16 months. We have been unable to find any record of such a case in which the brain was examined after such a long interval. In most of the delayed deaths recorded in the literature, temporary arrest of respiration and circulation had occurred at some time during anesthesia. In this case there was no cyanosis, cardiac

or respiratory failure observed at any time during the administration of the anesthetic, yet the patient afterwards manifested the symptoms now recognized to be indicative of cerebral damage; namely, failure to regain consciousness, muscular twitchings, convulsive seizures, restlessness, hypertonic or decerebrate phenomena and hyperthermia.

The cell changes are the result of anoxemia but just what mechanism is responsible for the cellular deprivation of oxygen is not clear. Courville[2, 3] reviews three groups of predisposing factors: (1) A congenital predisposition or idiosyncrasy. The respiratory center in such individuals may be hypersusceptible to the depressing action of nitrous oxide. This category includes individuals who are habitual alcoholics, allergic and those of a robust bodily habitus. (2) Some acquired cerebral or general disease such as pulmonary tuberculosis, heart disease, anemia, *etc.* (3) Disturbance of the reflex arc, such as the carotid sinus or visceral reflexes. Studies of the carotid sinus reflex reported by Weiss and Baker,[4] Ferris, Capps and Weiss,[5] Heymans and his associates,[6] and others, have contributed to a better understanding of the reflex control of the circulation, but there is no proof that this mechanism is the essential factor in this particular problem. All of these predisposing factors are little more than speculations. Considering that this patient had a prolonged period of unconsciousness after a very short nitrous oxide-oxygen anesthetic several years before, the idea of a predisposition or idiosyncrasy cannot be entirely disregarded. Such factors as defective apparatus, impurities of the nitrous oxide, and improper administration of the anesthetic are of practical significance in the prevention of some of these unfortunate accidents.

Because of the extensive damage to the cortex associated with destruction of most of the neostriatum (caudate nucleus and putamen) and the white matter of the central, parietal and occipital lobes on each side it is difficult to correlate the clinical picture with the anatomic changes. Since the patient had excellent nursing care and there was no history of trauma at any time, the subdural hemorrhage was thought to be the result of venous bleeding in the subdural space, possibly as the result of a combination of anoxemia and the convulsive seizures. The evidences of cortical irritation such as muscular twitching and convulsions later gave way to decerebrate phenomena and spasticity. How much the damage to the extrapyramidal motor system contributed to this picture is difficult to say. The cortical damage was sufficient to account for the intellectual defect as well as impairment of the visual system which, considering the occipital lobe damage, must have been present.

The failure to obtain a complete autopsy leaves important clinical observations unexplained. The cause of the blood in the stools is not explained. The hyperthermia is probably of central origin as it is characteristic of the clinical course in the encephalopathies following anesthesia.

The pathologic process is degenerative and not associated with any evidence of inflammation or a preceding damage to the vascular system. On the basis of the study of three other cases in which death was the result of a

similarly produced encephalopathy following other anesthetic agents, it is probable that the cerebral damage is the result of anoxemia regardless of the type of anesthetic used. A more complete neuropathologic study in which the question of local vulnerability of the brain in this and the other cases will be considered in a later publication.

REFERENCES

[1] Lowenberg, K., Waggoner, R., and Zbinden, Th.: ANNALS OF SURGERY, **104**, 801, 1936.
[2] Courville, C. B.: Medicine, **15**, 129, 1936.
[3] Courville, C. B.: ANNALS OF SURGERY, **107**, 371–379, March, 1938.
[4] Weiss, S., and Baker, J. P.: Medicine, **12**, 297, 1933.
[5] Ferris, E. B., Capps, R. B., and Weiss, S.: Medicine, **14**, 377, 1935.
[6] Heymans, C., Bouckaert, J. J., and Dautrebande, L.: Arch. Internat. de pharmacodyn. et de Thérap., **40**, 292, 1931.

BRAIN ABSCESS OF UNDETERMINED ETIOLOGY*

REPORT OF FOUR CASES WITH RECOVERY

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IT IS apparent from personal experience and from a review of the literature that in recent years the treatment of brain abscess has been more successful, and that complete, lasting recoveries have followed a correct diagnosis and proper treatment. However, the diagnosis of brain abscess may often be most difficult. In fact, a preoperative diagnosis of brain abscess depends, in the majority of instances, not only upon evidences of the existence of a space-taking lesion in the brain, but also upon the finding of a possible cause for the presence of an abscess. In other words, we do not consider a brain lesion as being an abscess unless we have some definite infectious process which may account for such a lesion.

The etiologic factors of brain abscess have been divided into three groups. Their relative frequency may best be appreciated by reference to the statistics compiled by Evans,[1] and Parker[2] (Table I).

TABLE I

ANALYSIS OF THE CAUSES OF BRAIN ABSCESS IN 216 CASES

(*Evans[1] and Parker[2]*)

(I) Direct Extension				
(1) Otitis media and mastoiditis			109	
(2) Suppuration in nose and accessory sinuses			12	
(3) Following trauma of skull			8	
(4) Invasion of skull by malignancy			2	
Total			131	(Evans)
(II) Hematogenous Spread (Metastatic)				
(1) Intrathoracic suppuration	22		14	
(2) Extrathoracic suppuration	26		6	
Totals	48	(Evans)	20	(Parker)
Osteomyelitis and cystopyelitis were the most common initial lesions in this group. General sepsis occurred in the majority of cases.				
(III) Source of Infection Doubtful or Unknown			17	(Evans)

It is important to emphasize the fact that while the brain abscess usually develops in the course of acute infection in both Groups I and II, it may also

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be secondary to an infection that has subsided. This latter etiologic factor was found by Evans as a doubtful source of infection in seven of the 17 cases in Group III. The relative incidence of a preceding infective process in these cases was: Sinus disease, 2 cases; earaches, 2 cases; severe quinsy five months before, 1 case; carbuncle 14 months before, 1 case; and pneumonia followed by a pneumococcic arthritis, 1 case. In ten cases he was unable to determine any causative factor. We have encountered, within a period of nine months, four cases of brain abscess of undetermined etiology. All of them were operated upon and recovered.

CASE REPORTS

Case 1.—E. S., female, age 20, was admitted to the Graduate Hospital, September 12, 1936, complaining of pain in the head and neck, vomiting, and blurring of vision. Her mother died 18 years ago of tuberculosis; other than that her family and past medical history were negative. There was no history of chronic cough, running ears, sinus infection or any other infective process. About three months prior to admission she had had a tonsillectomy performed, under local anesthesia, without any untoward effects. Six weeks later she began to complain of headache and somewhat later of diplopia, loss of vision and vomiting. During the few days preceding admission the pain in the head had become severe. On admission her temperature was 99.3°; pulse, 64; respirations, 22; blood pressure, 118/90. She was mentally clear, had some rigidity of the neck, a bilateral Kernig, a bilateral papilledema of about 3 to 4D, a cut in the left temporal field, weakness of both external recti, more marked on the left than on the right, a paralysis of both seventh nerves, more marked on the right than on the left, and no significant changes in the extremities. The spinal fluid pressure was 350 Mm. of water, and the spinal fluid contained five lymphocytes.

The lumbar puncture relieved the headache for two days, after which it recurred with greater severity. The temperature varied between normal and 99.0° F., the pulse varied between 64 and 100, and the blood pressure remained fairly constant. Uranalyses were negative. The blood picture showed a mild secondary anemia, 12,800 leukocytes, 88 per cent polymorphonuclears. The blood Wassermann was negative. The stools showed ova and segments of *Taenia saginata*; the patient's father recalled that she had had a tapeworm many years before. Roentgenologic examination of the skull and the paranasal sinuses revealed no abnormalities. The lumbar puncture was repeated September 18, 1937, and showed a pressure of over 700 Mm. of water, and the spinal fluid contained 15 cells, but was otherwise essentially negative.

It was felt she had a space-taking lesion, but owing to the confusing neurologic signs, especially the presence of the bilateral sixth and seventh nerve paralyses and the marked increased intracranial pressure without any cerebellar symptoms, localization was difficult.

Operation.—September 19, 1936, by Dr. F. C. Grant: A ventriculogram showed a mass lesion on the right side, probably in the frontoparietal lobe. Accordingly, a right frontotemporal bone flap was reflected. The dura was extremely tense and upon its reflection the sylvian fissure was seen to be pushed up by a mass beneath the surface and within the substance of the tip of the right temporal lobe. A transcortical incision was made over the tumor, which was removed without rupture. It measured 3½ x 4 x 5 cm. The patient made a rapid and uneventful convalescence. All neurologic signs disappeared and she has remained well to date.

Pathologic Examination.—Section of the tumor revealed a capsule 0.5 cm. thick, filled with fibrinopurulent exudate. Microscopic examination of the capsule showed it to be composed of a stout fibrous stroma, in which many short glia fibrils were to be

seen together with numerous blood vessels, many of which showed proliferative changes. Plasma cells, lymphocytes and old polymorphonuclear cells were present.

Comment.—The evidences of increased intracranial pressure pointed to a space-taking lesion, but clinical localization seemed impossible because of the presence of the bilateral combined sixth and seventh nerve paralyses. The clinical findings in this case are almost identical with those occurring in a case of a verified brain tumor reported by Spiller.[3] There was no etiologic factor to suggest the presence of an abscess. The tonsillectomy, three months previously, was not followed by any pulmonary complications, as in the case reported by Gardner,[4] or by any other known infection. Even at operation both this and Case 2 were treated as brain tumors and were removed en masse as in the case reported by Parker.[2] The slow pulse and the severe headache were noted but not duly evaluated.

Case 2.—J. F. M., male, age 26, single, occupation, weighman, was admitted to the hospital of the University of Pennsylvania, January 12, 1937, complaining of severe headache, partial loss of vision in the left eye, pain in the left shoulder and arm, and dizziness and loss of weight. The family and past medical history were irrelevant. On October 1, 1936, without any previous infection or injury, he began to have projectile vomiting. A week later he began to have left fronto-occipital headache. The pain was constant, increased in severity, and by January, 1937, radiated to the right frontal region; in addition he experienced difficulty with vision in the left eye. About November, 1936, he complained of some pain in the left shoulder and arm, became dizzy when bending over, and noted that in walking he tended to swerve to the right. Notwithstanding the loss of approximately 20 pounds in weight, he did not discontinue working until January 10, 1936.

Physical Examination.—The patient was a well nourished male. Temperature, 98° F.; pulse, 64; respirations, 18; blood pressure, 112/60. The general somatic examination was negative excepting for large cryptic tonsils, a postnasal drip and some dental sepsis. The neurologic examination revealed bilateral choking of the optic disks, right 4D, left 5D with hemorrhages; contraction of the visual fields, especially in the right temporal field, suggestive of a right homonomous hemianopia; left abducens palsy; either weakness or dyssynergia of right extremities with a right-sided Tremnor-Hoffman sign, a hyperactive right Achilles tendon reflex and an abortive right ankle clonus; some loss of sense of position in the right hand; and some dysarthria. Uranalysis and Wassermann tests were negative. Leukocyte count, 10,600. A spinal tap was not performed. Roentgenologic examination revealed erosion of posterior clinoid processes and the dorsum sellae, with some forward displacement of the top of the dorsum. Roentgenologic Diagnosis: Probably an extrasellar mass lesion. During the period of preoperative observation his pulse varied between 56 and 84 while the temperature and respirations remained normal.

Preoperative Diagnosis.—Brain tumor, either in the left frontal, left occipital or right cerebellar regions.

Operation.—January 21, 1937, by Dr. F. C. Grant: Two trephine openings were made over the tips of the posterior horns of the lateral ventricles. In attempting to tap the right posterior horn, the cannula encountered a firm mass which was thought to be a tumor. Predicated upon this finding a left occipitoparietal bone flap was reflected. A massive tumor, only slightly adherent to the dura, was seen on the surface of the cortex. The mass was removed without rupture of the capsule.

Postoperative Course.—After a moderately prolonged convalescence the patient

was discharged. The neurologic picture of right lower facial weakness, dysasthesia, and hyperactive reflexes on the right side were rapidly disappearing.

Pathologic Examination.—The mass weighed 65½ Gm. and measured 6 by 4.5 by 3.5 cm. It had a thick fibrous capsule which contained a few large vessels. The contents consisted of a large amount of thick, green pus. Microscopically, the capsule was composed of a dense, central fibrous structure arranged in parallel rows of collagen. Among these fibers were numerous fibroblasts and scattered polymorphonuclear cells. The under surface of the capsule had a loose fibrous mesh in which there were numerous polymorphonuclear cells. Attached to the outer side of the capsule was an area of gliosis which contained very large, plump astrocytes lying in a very dense glial carpet. In this were scattered ganglion cells. This consisted apparently of adjacent brain tissue. Pathologic Diagnosis: Abscess of capsule.

Comment.—This case has a number of points in common with Case 1: Slow pulse, severe headache, evidences of increased intracranial pressure, confusing localizing signs, the removal of the tumor en masse and lack of all etiologic infective factors.

Case 3.—M. S., male, age 26, clerk, was admitted to the Graduate Hospital January 16, 1937, complaining of a severe left frontal headache and vomiting. The family and past medical history were irrelevant. There was no history at any time of a running ear, sinus infection, persistent cough, head injury, or of any recent infections. On January 11, 1937, without any premonitory symptoms he developed generalized convulsions accompanied by complete loss of consciousness, followed by a period of confusion and, somewhat later, by severe headache over the left frontal region and by vomiting.

When first seen, January 15, 1937, he showed mental dulness, some expressive aphasia, and a right central facial palsy. Pulse, 52; temperature and blood pressure, normal. Upon admission to the hospital the following day, he showed an increase of the above mentioned symptoms and signs, his pulse became as slow as 44, and, in addition, he showed a right sided hemihypalgesia. The fundi and fields of vision showed no definite abnormalities or at most 1D of swelling. Blood count, normal; uranalyses, negative. The spinal tap showed a pressure of 350 Mm. of water and only two lymphocytes in the spinal fluid. Roentgenologic examination of the skull and sinuses was negative. Diagnosis: A space-taking lesion in the left frontoparietal region.

Operation.—January 17, 1937, by Dr. R. A. Groff: A left subtemporal decompression was performed and after opening the dura about one and one-half inches, an abscess ruptured through the cortex. The hole through which the pus was discharging was plugged. A smear showed Streptococci, about seven chains per high power field. The pus was washed from the surface of the brain and dura by alcohol and the entire wound packed with iodoform gauze. Two days later the packing and the plug over the mouth of the ruptured abscess were removed. About one and one-half ounces of pus were discharged, and a rubber tube was introduced into the focus from which the pus was coming. Three weeks later, drainage having ceased, the tube was removed. Several days later a cerebral fungus developed. By the fifth week postoperative, however, it had receded to such an extent that secondary wound closure was possible. The wound was completely healed at the end of the forty-fifth postoperative day. For the first three weeks following operation the patient was given large doses of both prontylin and prontosil.

Subsequent Course.—The patient was seen four months after operation and was free from all symptoms except for a slight hesitancy in speech. The neurologic examination was negative.

Comment.—In this case, despite the absence of any source of infection, the severe, unilateral headache, the slow pulse and the evidence of increased intracranial pressure raised the suspicion of a brain abscess. The localization in this case was clear. The rôle of prontylin and prontosil in the recovery is difficult to evaluate.

Case 4.—W. P., male, age 19, was admitted to the Philadelphia General Hospital April 27, 1937, complaining of severe headache. The family history was irrelevant. At the age of 14 he sustained a fracture of the right frontoparietal region and since then showed behavior disorders with antisocial tendencies. In November, 1936, he received a blow on the head and was momentarily stunned. There was no laceration of the scalp. Two weeks later he began to have pain over the right frontal region and in the right eye. The pain continued until December 22, 1936, when he developed generalized convulsions accompanied by complete loss of consciousness. He was then free from symptoms until January 14, 1937, when he had another convulsion. During the succeeding few weeks he was free from headaches except when he coughed, jumped or ran. However, he became progressively drowsier and on April 27, 1937, developed severe frontal headaches, more marked on right side, and projectile vomiting. There was no history of any upper respiratory infection, furunculosis, or of a chronic cough.

On admission the pulse was 50; temperature, 99° F.; blood pressure, 130/76. He showed some clouding of consciousness and screamed with pain despite opiates. He presented scars over the right frontotemporal region from previous injuries, tenderness on percussion over the same area and dilatation of the veins of the right temporal region. There was slight blurring of the disks but no other positive neurologic abnormalities. Uranalysis, blood and Wassermann were negative, and other routine laboratory studies revealed no significant changes. The spinal fluid pressure was 21 Mm. of mercury and the fluid contained 281 cells, 24 per cent polymorphonuclears and 76 per cent lymphocytes. The roentgenologic finding reported *after* the operation were: No evidence of any old or recent fracture, or of increased intracranial pressure. There was rarefaction in the right frontal bone just to the outer side of the frontal sinus. There was also sclerosis of the right sphenoidal ridge but the frontal sinuses were well outlined and appeared normal.

Operation.—April 30, 1937, by Dr. R. A. Groff: A trephine opening was made over the right frontal lobe just above the fascial attachment of the temporal muscle. An exploratory cannula was introduced into the substance of the right frontal lobe, directed toward the midline and anteriorly. At a depth of about 3 cm. increased resistance was felt. The cannula was advanced farther and entered a cavity from which about 30 cc. of greenish-yellow pus were evacuated. The abscess cavity was then washed out with normal saline solution. The cannula was left *in situ* and dressings applied. Forty-eight hours later the cannula was removed as there had been no drainage through it, and because lavage of the cavity through it did not disclose any residual pus. Culture of the pus revealed the infecting organism to be a pneumococcus Type IV. Three weeks following the operation the patient was symptomatically well and no neurologic signs could be demonstrated.

Comment.—In this case, also, the source of the infection is extremely doubtful. There existed some reason to incriminate the right frontal sinus but a critical study of the sinuses was negative. The history of repeated injuries suggested the possibility of a chronic subdural hematoma. However, the agonizing, unilateral headache, the slow pulse and the pleocytosis justified a preoperative diagnosis of brain abscess.

DISCUSSION.—In three of the four cases no etiologic factor could be determined. In the fourth case the proximity of the abscess to the frontal sinus and repeated injuries may be conceived as possible causative factors. It is reasonable to assume that these cases, in addition to those reported by Evans,[1] must be of metastatic origin. One might infer that the initial infection may have subsided and having been mild, was entirely forgotten. It is also conceivable that the focus of infection was dormant and thus evaded detection. The abscess was *single* in each of the four cases. King,[5] after reviewing the literature, concludes that 50 per cent of metastatic brain abscesses are single lesions.

TABLE II

SYNOPSIS OF THE CLINICAL MANIFESTATIONS IN FOUR CASES OF BRAIN ABSCESS OF UNDETERMINED ETIOLOGY

	Case 1 Right Frontal	Case 2 Left Frontoparietal	Case 3 Left Frontoparietal	Case 4 Right Frontal
Temperature	Normal to 99.3° F.	Normal	Normal	Normal to 99.3° F.
Pulse	64	64	44 to 60	44 to 60
Mental state	Clear	Clear	Clouded	Clouded
Severity of headache	Marked	Marked	Marked	Marked
Unilateral headache	General	More marked on left	Entirely on left	More marked on right
Papilledema	3 to 4 D	4 to 5 D	1 D	Slight blurring
Fields of vision	Slight cut in left temp. field	Slight cut in right temporal field	Normal	Normal
Spinal fluid pressure	350 to 700 Mm. water	No tap	350 Mm. water	21 Mm. Hg.
Cells in spinal fluid	5 to 15	Not examined	2 cells	281
Localizing neurologic signs	Misleading	Indefinite	Definite	Only unilateral headache
X-ray studies	Negative	Indefinite	Negative	Inconclusive
Requiring ventriculography	Yes	Yes	No	No

The duration of symptoms prior to operation in Case 1 was six weeks, in Case 2 three months and three weeks; in Case 4 seven months; and in Case 3 only six days. In Cases 1 and 2 the abscesses were large (measuring 3.5 by 4 by 5 cm. and 6 by 4.5 by 3.5 cm. respectively) and so heavily encapsulated that at the time of operation the lesions were removed en masse as it was

thought that they were solid tumors. In Case 4 the lesion was also encapsulated. In Case 3 there was no encapsulation, and this may be regarded as the only acute abscess in this series.

The analysis of the clinical manifestations (Table II) suggests some diagnostic criteria. In all of the four cases there were evidences of increased intracranial pressure. In three cases there was marked increase in intraspinal pressure while no lumbar puncture was performed in the fourth case. Two of the cases showed marked choking of the disks, while the other two showed only slight blurring of the disk margins. The pulse was slow in all four cases which contrasts markedly with the normal or nearly normal temperatures. These evidences of increased intracranial pressure are more diagnostic of brain tumor than brain abscess. However, the slow pulse rate has long been known to be suggestive of a brain abscess (Gowers,[6] Oppenheim,[7] Bailey[8]). In addition to the slow pulse the excruciating headache, observed in all four cases, was more suggestive of an acute meningitis than of a brain tumor.

The evidences pointing to the existence of infection were meager: The temperature was normal or nearly so in all cases. The leukocyte count was slightly increased in two cases and normal in the other two. In only one instance was there a marked increase of cells in the spinal fluid. The localizing symptoms were no clearer than in the average case of brain tumor and ventriculography was needed in two cases in order to definitely localize the lesion. However, the pain in the head was definitely ipsilateral with the lesion in one case and more marked on the side of the abscess in two other cases.

From personal observation of a considerable number of intracranial space-taking lesions and from a study of these four cases, it appears that the combined occurrence of severe, especially unilateral, headache, a persistent slow pulse, and some evidences of increased intracranial pressure should suggest, even in the absence of any evidence of infection in the nervous system or elsewhere in the body, the existence of a brain abscess. The suspicion of an abscess may then be followed by exploration, and since 50 per cent of these abscesses are solitary, timely and appropriate operative procedures will result in a greater number of recoveries. In the present series the first three cases may be regarded as having made a full recovery, while the fourth is still convalescing.

SUMMARY.—Four cases of solitary cerebral abscesses of undetermined etiology are reported. All the cases recovered following operation. In two cases the abscesses were so heavily encapsulated that they were removed en masse at operation as it was thought that they were solid tumors.

CONCLUSIONS

From the study of these cases, it is submitted that the combined occurrence of severe, especially unilateral headaches, a persistent slow pulse, and evidences of increased intracranial pressure should suggest, even in the absence of evidences of infection in the nervous system or elsewhere in the body,

the existence of a brain abscess. Timely diagnosis is indispensable in the surgical treatment of brain abscess.

REFERENCES

[1] Evans, W.: Pathology and Etiology of Brain Abscess. Lancet, **1**, 1231, June 6, and 1289, June 13, 1931.

[2] Parker, H. L.: Metastatic Abscesses of the Brain: A Clinical Study. Am. Jour. Med. Sci., **180**, 699, 1930.

[3] Spiller, W. G.: Bilateral Paralysis of Facial and Abducens Nerves as a Remote Effect of Tumor of the Brain. ANNALS OF SURGERY, **101**, 329, 1935.

[4] Gardner, W. J.: Metastatic Abscesses of the Brain of Pulmonary Origin: Report of Two Cases. Arch. Neur. and Psych., **19**, 904, 1928.

[5] King, J. E. J.: Acute Metastatic Brain Abscess. Southern Surg., **5**, 407, 1936.

[6] Gowers, W. R.: A Manual of Diseases of the Nervous System, **2**, 482, Philadelphia, 1893.

[7] Oppenheim, H.: Lehrbuch der Nervenkrankheiten. Karger, **2**, 1359, Berlin, 1923.

[8] Bailey, P.: Intracranial Tumors. C. S. Thomas, p. 411.

TREATMENT OF HEMORRHAGE AND TRAUMATIC SHOCK BY THE INTRAVENOUS USE OF LYOPHILE SERUM *

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METHODS for the preservation of normal blood serum in desiccated form have been developed by Elser, Thomas, and Steffen,[1] by Reichel and his associates, and by Flosdorf and Mudd.[2] Essentially this procedure is one of rapid freezing at a very low temperature and rapid dehydration from the frozen state under high vacuum. This leaves in dry form all the solid elements of serum. The proteins appear to be unaltered and their antibody properties are preserved in full titre. In this form serum may be preserved for extended periods and is readily dissolved in water to make an isotonic or hypertonic solution. Because of its rapid solubility this product is called "lyophile." For intravenous use serum must be processed twice by this method, with an intermediate filtration to remove fat particles.[3]

In these experiments we have used solutions of lyophile serum intravenously to treat animals which were moribund after experimental shock and hemorrhage. This use has been suggested by Hughes, Mudd, and Strecker,[4] on the basis of their intravenous use of hypertonic lyophile serum in human and animal subjects for lowering cerebrospinal pressure. Hughes has treated a case of shock with serum in conjunction with blood transfusion.

The decrease in circulating blood volume found in secondary shock is regarded as a centrally important occurrence in this syndrome. The mechanism by which this reduced blood volume is achieved is not completely understood, but there exists considerable knowledge as to what are the most important substances lost from the blood stream. Johnson and Blalock,[9] in agreement with earlier workers, have stressed that the plasma was the portion of the blood that was most severely reduced and that in this severe plasma loss it was the escape of the plasma proteins that was of most importance.

Clinical treatment of patients suffering from surgical shock has been directed largely toward the restoration of the blood volume in general and of the plasma proteins in particular. By far the most satisfactory and most logical substance used for this purpose has been whole blood. As whole blood must be typed, is expensive, and is not always readily available, other substances have been substituted with considerably less therapeutic success. The best of these is acacia, used in a solution osmotically similar to plasma, but it occasionally has toxic properties that weigh against its use. The deleterious

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effect of acacia upon the liver and upon the gaseous exchange of the red blood cells has been stressed by Studdiford.[6] It is thought by some workers that, in practice, blood demonstrates its superiority to acacia solutions, appearing to stay in the blood stream longer than acacia despite its somewhat similar osmotic properties. This view has been expressed by Wangensteen.[7] Glucose and salt solution in various strengths have been widely used, but their diffusibility is so great that the increase of circulating blood is very transient, and with salt solution in particular there is danger of edema. Blalock has evidence that not only do these latter substances diffuse rapidly because of their own molecular size, but, because they dilute the plasma protein, they reduce the effective osmotic pressure.[8]

It has been shown that animals tolerate better the loss of whole blood than they do of similar volumes of plasma or of cells.[9] Harkins has given experimental evidence to the effect that plasma transfusion is effective in combating experimental shock and has indicated that this procedure is of even more therapeutic value than is whole blood transfusion.[10]

Method.—Thirty-one dogs were used and, for the most part, were under light ether anesthesia administered by tracheal cannula. A few were under sodium amytal, given intraperitoneally—50 mg. per kg. of body weight. During periods of trauma the ether anesthesia was deepened.

Mean blood pressure was measured by a mercury manometer connected with a cannula in either the femoral or carotid arteries. Blood pressure readings were taken at five minute intervals, and pulse and respiratory rates were taken at longer intervals.

After control observations of 10 to 15 minutes, the animals were subjected to intestinal manipulation, to trauma of the hind legs, or to repeated hemorrhages. The severity of these procedures was such that control dogs of each group died. It is improbable that any of the animals, treated or untreated, would have survived the effects of the procedures. The animals exhibited the clinical symptoms of shock: Pale mucous membranes, apathy with reduced need for anesthesia, reduced pulse pressure, commonly a lowered body temperature, increased or decreased pulse rates, and prolonged hypotension. The respiratory rate seemed too greatly influenced by the anesthesia to be significant. The length of time that the blood pressure was reduced, and the height of the mean blood pressure were taken as the chief criteria of shock. The height of the blood pressure was taken as a reliable indication because it is generally agreed that although the blood pressure may remain high when the animal is in shock, it cannot be greatly reduced for long without indicating or causing a shocked condition. (Bayliss,[13] Mann,[11] Erlanger and Gasser,[12] Blalock.[5]) Before restorative therapy was started, in all but one case, the mean arterial pressure fell below 50 Mm. Hg. and was maintained below 60 Mm. Hg. for periods of one-half to two hours depending upon the rapidity of the fall to very low levels and upon the height of the original blood pressure.

When serum was used it was dissolved in water to make its original volume or one-quarter of its original volume, brought to body temperature, and injected

intravenously. (Serum dissolved in one-quarter its original volume is referred to as "four times concentrated," or as "hypertonic.") In control animals, solutions of 6 per cent gum acacia in normal saline (Lilly), normal saline, and 3.6 per cent saline were injected, so as to evaluate the severity of the condition produced by our methods. Other control animals received no treatment.

Intestinal Manipulation.—(12 experiments): Eleven dogs in this group were anesthetized with ether and one with sodium amytal. After a blood pressure control period of 10 to 15 minutes the small gut was delivered through the abdominal wall and rolled or squeezed for periods varying from 15 minutes to one and one-half hours. In the experiments in which the initial manipulation was short, there was added manipulation at regular intervals until the mean arterial pressure had dropped below 50 Mm. Hg. This procedure took from one and one-half hours to seven and three-quarter hours after the start of the manipulation in the various experiments. After the pressure had remained at a low level for periods of one-half to one and one-half hours, during which time it fell progressively in all cases, solutions were

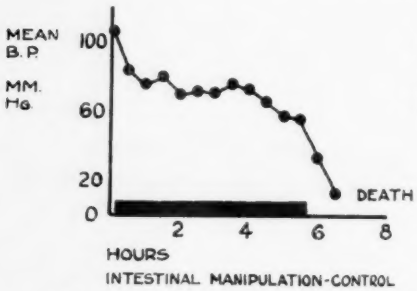

CHART 1.—Mean blood pressure in shock produced by intestinal manipulation. Dog anesthetized with ether by Woulff bottle. Gut manipulated during five and one-half hours as shown by heavy black line along abscissa.

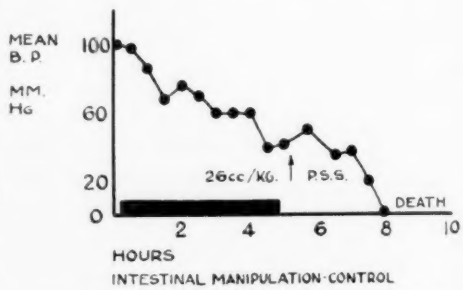

CHART 2.—Mean blood pressure in shock produced by intestinal manipulation. Intravenous injection of 0.9 per cent NaCl solution, 26 cc. per kg. of body weight. Dog under ether. Gut manipulated during five hours as shown by heavy black line.

injected intravenously and the experiments watched for one and one-quarter to three and one-quarter hours longer.

Results.—Four animals were used as controls and three of these received no injections or treatment. Two of those untreated died quickly; the third was progressively failing when he was killed. The fourth received a large dose of concentrated saline solution and died within two and one-half hours (Table I; Charts 1 and 2).

In the six experiments in which serum was given, there was a considerable rise in blood pressure from the injection level (Table I; Charts 4 and 5). In four of the experiments the blood pressure showed no evidence of falling from the higher level during the periods after injection that these experiments were watched. These periods varied from one and one-half to two and one-half hours. The blood pressure at the time of injection in these four experiments ranged between less than 10 and 39 Mm. Hg.

In the two experiments in which the blood pressure fell off markedly after

serum injection, the blood pressures were 25 and 27 Mm. Hg. at the time of injection. One animal showed a marked initial rise and slow fall to death. The other was not much benefited by injection and, after a short initial blood pressure rise, died within an hour and one-quarter after injection.

Two animals were given solutions of 6 per cent gum acacia in 0.9 per cent saline (Lilly) in doses comparable to those used of serum. While the life of one of these dogs was probably considerably prolonged, there was no sustained rise in blood pressure in either (Table I; Chart 3).

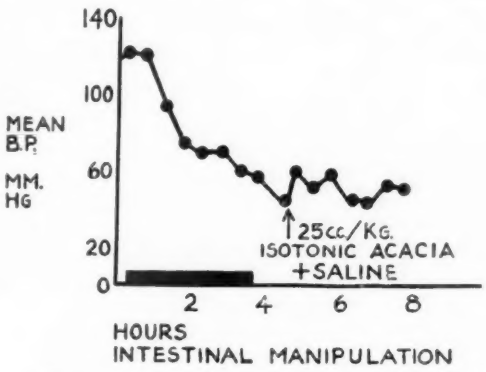

CHART 3.—Mean blood pressure in shock produced by intestinal manipulation. Intravenous injection of 6 per cent gum acacia +0.9 per cent NaCl solution, 25 cc. per kg. of body weight. Dog under ether. Gut manipulated during three and one-half hours as shown by heavy black line.

The observations were not extensive enough to show appreciable differences in the blood pressure effects obtained from the injection of hypertonic and isotonic serum.

The dose given in these experiments varied from 5 to 7 cc. per kilogram of the hypertonic serum, and was 20 cc. per kilogram of the isotonic serum. Calculating the hypertonic solution in its hypothetical final dilution, this would mean that serum equivalent to about 2 per cent of the body weight was injected.

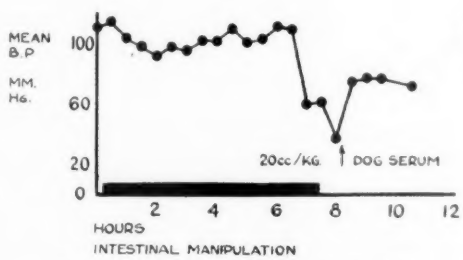

CHART 4.—Mean blood pressure in shock produced by intestinal manipulation. Intravenous injection of isotonic solution by lyophile dog serum, 20 cc. per kg. of body weight. Dog under ether. Gut manipulated during seven and one-half hours as shown by heavy black line.

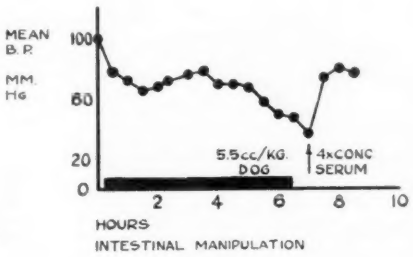

CHART 5.—Mean blood pressure in shock produced by intestinal manipulation. Intravenous injection of hypertonic (four times concentrated) solution of lyophile dog serum, 5.5 cc. per kg. of body weight. Dog under ether. Gut manipulated during six hours as shown by heavy black line.

Trauma to Hind Leg.—(Six experiments): Three animals, two under ether anesthesia, and one under sodium amytal, were given concentrated solutions of serum after they had been shocked by trauma to an extremity. Trauma was administered by striking one or both hind legs with a dull instrument. The skin was broken in small areas, and in most cases the femur or tibia were fractured. The state of the animal was judged by its clinical condition as well as by the drop in blood pressure. Two experiments showed that dogs

TABLE I

INTESTINAL MANIPULATION

No.	Wt. of Dog in Kg.	Initial Mean Blood Press. Mm. Hg.	Mean B. P. Falls to 60 Mm. Hg. No. of Hrs. after Start of Trauma	Length of Time Mean B. P. below 60 Mm. Hg., Hrs.	Mean B. P. at Time of Injection Mm. Hg.	Solution Given, Amount and Concentration	Mean B. P. after Injection Mm. Hg.				Remarks
							½ Hr.	1 Hr.	2 Hrs.	Final Mm. Hg. in — Hrs.	
1.	3.8	140	½	....	....	.....	....	....	....	....	Dead 1½ hrs. after start of trauma
2.	14.0	106	4¾	1½	....	.....	....	....	....	....	Chart 1 Dead 6¼ hrs. after start of trauma
3.	20.0	100	2	¾	....	.....	....	....	....	....	Exp. terminated with B. P. at 46 Mm. Hg.
4.	6.4	100	3¼	¾	40	26 cc. per Kg. 3.6% saline	58	35	26	2½ dead	Chart 2
5.	7.0	125	2¼	1	41	25 cc. per Kg. 6% acacia + .9% saline	71	60	....	1½ dead	
6.	8.7	120	2½	1½	43	25 cc. per Kg. 6% acacia + saline	60	53	46	52 3 hrs.	Killed 3½ hrs., Chart 3
7.	7.4	110	6½	1	39	20 cc. per Kg. isotonic serum	76	78	65	72 2½ hrs.	Killed, Chart 4
8.	7.2	110	6	¾	25	20 cc. per Kg. isotonic serum	80	82	52	3¼ dead	
9.	7.0	125	7¾	¾	30	7 cc. per Kg. 4x concentrated serum	87	87	....	84 1¼	Killed
10.	6.9	100	5	2	36	5 cc. per Kg. 4x concentrated serum	73	76	....	78 1½	Killed, Chart 5
11.	7.8	84	6½	1	less than 10	6 cc. per Kg. 4x concentrated serum	37	56	....	57 1¼	Killed
12.	4.4	70	1¼	1½	27	5 cc. per Kg. 4x concentrated serum	54	8	....	1¼ dead	

TABLE II

TRAUMA TO HIND LIMB

No.	Wt. in Kg.	Initial Mean Blood Pres. Mm. Hg.	Mean B. P. Fell to 60 Mm. Hg. No. of Hrs. after Start of Trauma	Length of Time Mean B. P. below 60 Mm. Hg., Minutes	Mean B. P. of Time of Injection Mm. Hg.	Solution Injected	Mean B. P. after Injection Mm. Hg.				Remarks
							¼ Hr.	1 Hr.	2 Hrs.	Final Mm. Hg. in — Hrs.	
1.	6.6	85.0	1	25	44	10 cc. per Kg. 3.6% saline solution	68	48	Dead	....	Amytal
2.	6.3	80.0	1	45	47	10 cc. per Kg. 4x concentrated serum	68	70	68	63 6¼ hrs.	Amytal, killed
3.	6.0	120.0	....	....	64	16 cc. per Kg. 4x concentrated serum	80	100	90	115 5 hrs.	Ether, killed. Chart 6
4.	5.2	120.0	¾	70	32	5 cc. per Kg. 4x concentrated serum	76	64	....	60 1½ hrs.	Both legs were traumatized. Ether, killed

subjected to such trauma go into shock and die. The condition of the animal prior to serum injection is probably as good a control for shock as can be obtained.

Results.—One control dog was given 3.6 per cent saline solution in the same dosage as was used of serum, and died one and one-half hours later (Table II, Experiment 1).

In the group in which serum was administered the blood pressures ranged from 32 to 64 Mm. Hg. at the time of injection (Table II). Previous to injection Dog No. 2 had a very similar blood pressure fall to that shown by the dog receiving concentrated saline solution. Although the serum injection did not effect a high rise in pressure the rise was maintained for the six and one-quarter hours after injection during which the experiment was followed.

The secondary fall in pressure shown by Dog No. 3 (Chart 6) subsequent to serum injection was due, partially at least, to manipulation of the injured

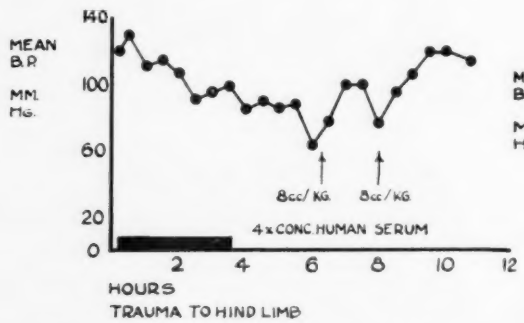

CHART 6.—Mean blood pressure in shock produced by trauma to hind limb. Intravenous injection of hypertonic (four times concentrated) solution of lyophile dog serum. 16 cc. per kg. of body weight. Dog under ether. Gut manipulated during three and one-half hours as shown by heavy black line.

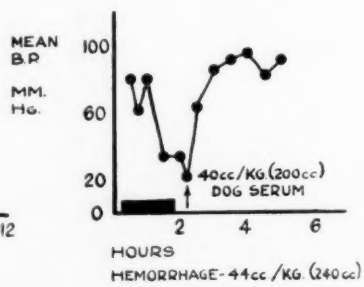

CHART 7.—Mean blood pressure in hemorrhage. Intravenous injection of isotonic solution of lyophile dog serum. 40 cc. per kg. of body weight. Dog under ether. Hemorrhage of 44 cc. per kg. of body weight, during one and one-half hours, as shown by heavy black line.

leg. The second injection given this dog showed a very substantial and sustained rise in pressure.

Dosage of serum ranged from 5 to 16 cc. per kilogram of body weight of hypertonic serum.

Hemorrhage.—(Eight experiments): The following experiments were undertaken to determine the effect of lyophile serum upon dogs subjected to acute hemorrhage. Blood in amounts of 2.1 to 4.0 per cent of the body weight was taken from the femoral artery over periods of one-half to one and one-half hours. The blood pressure reaction of control animals was seen to vary widely to hemorrhages of comparable amounts. It was thought, therefore, that good controls for the experiments in which serum was tested was the state into which the animals had progressed before injection.

Results.—Hypertonic saline solutions were tested and did not bring about lasting elevations of blood pressures which were lowered as much as those cited below.

TABLE III

HEMORRHAGE

No.	Wt. in Kg.	Initial Mean B. P. Mm. Hg.	Method of Bleeding	Per Cent Body Wt. Bled	Length of Time Mean B. P. below 60 Mm. Hg., Minutes	Mean B. P. at Time of Injection Mm. Hg.	Solution Injected	Mean B. P. after Injection Mm. Hg.				Remarks
								¼ Hr.	1 Hr.	2 Hrs.	Final Mm. Hg. in — Hrs.	
1.	8.2	130	2.4% of body wt. at one bleeding, 1.2 % later	3.7	20	29	8.5 cc. per Kg. 4x concentrated serum	103	108	85	84 2½ hrs.	B. P. fell spontaneously for 20 min. after last bleeding. Under amytal 3½ hrs. previous to this expt. Killed
2.	3.7	100	2.5% at one bleeding, .7% 20 min. later	3.2	30	22	6.5 cc. per Kg. 4x concentrated serum	112	73	60	76 3 hrs.	B. P. fell spontaneously for 10 min. after last bleeding. Ether, killed
3.	7.3	100	.4% at 5–10 min. intervals	2.1	60 45 min. at 30 Mm. Hg.	30	12 cc. per Kg. 4x concentrated serum	82	92	..	93 1½ hrs.	B. P. fell spontaneously for 30 min. after last bleeding. Under amytal for 8 hrs. previously. Killed
4.	5.5	82	Bled in small amounts over 70 min.	4.0	30	22	40 cc. per Kg. isotonic serum	72	84	94	92 3 hrs.	B. P. fell spontaneously for 30 min. after last bleeding. Ether, killed. Chart 7
5.	3.8	120	Bled in small amounts over 1 hr.	4.0	50	30	40 cc. per Kg. isotonic serum	70	62	65	63 4½ hrs.	B. P. did not rise for 15 min. after last bleeding. Ether, killed

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All the animals in which serum was injected had been subjected to mean arterial pressures below 60 Mm. Hg. for 20 minutes to one hour; all had fallen spontaneously to 30 Mm. Hg. or below before injection. After the serum had been introduced, the blood pressure was maintained at much higher levels for periods up to four and one-half hours (Table III; Chart 7). Dosages of serum were 40 cc. per kg. of isotonic serum, and from 6.5 to 12 cc. per kg. of hypertonic serum. Acacia in one experiment produced a rise in pressure similar to that given by serum injection.

Amytal.—(Five experiments): Five animals with steadily declining blood pressures, resulting presumably from an overdose of sodium amytal and some surgical trauma, were given small doses of serum and showed marked rises in pressure that persisted for some hours. At the time of injection the blood pressures were between 30 and 50 Mm. Hg. and had reached this level by a slow drop, taking one to three hours. The pressures rose to higher levels where they remained as long as four and one-half hours after injection.

Discussion.—The methods of producing shock used in these experiments are methods which, in large part, have defined the term "secondary shock" as seen in the laboratory. An outstanding symptom of secondary shock, seen either clinically or experimentally, is the low mean blood pressure, and its measurement has proved to be the most reliable criterion of judging the degree of shock, with the exception of blood volume determinations and of Freeman's blood flow measurements.[14]

The relatively short duration of these experiments detracts from the significance of the results. This is offset, to some degree, by the severity of the shocked state to which these animals were allowed to progress before the injection of serum was started. Control animals in all groups of experiments died shortly after their blood pressures had reached levels comparable to the blood pressure levels at the time of injection in the treated dogs. The relative ineffectiveness of acacia in restoring the animals shocked by intestinal trauma also indicates the severity of the type of shock produced. Various authors place the "shock level" of mean blood pressure between 70 and 30 Mm. Hg. The objective of these experiments was to produce a degree of circulatory failure such that the animal could not recover. In all but one experiment, therefore, the mean pressure was reduced to a level well below 50 Mm. Hg. and allowed to remain low for long periods.

Although graded hemorrhage seems to be a well established method of producing shock, the method of bleeding used here was so acute that the animals were considered to be suffering primarily from a loss of whole blood.

The response of the heart rate to the procedures used was variable. Commonly, in those animals subjected to hemorrhage, the rate increased following bleeding, as, in one case, from 132 to 180 beats per minute. After long manipulation of the gut, the rate was often seen to be slowed, as from an

initial 165 to 106 beats per minute. This slowing of the heart was seen to occur also after trauma to the hind legs, in one case from 130 to 92 beats per minute. Such a response, however, did not always take place—the pulse in another animal increasing from 150 to 180 beats per minute. In one case, with an original pulse of 117, and hemoglobin of 90, the pulse fell to 94, and the hemoglobin rose to 94; then the pulse rose to 100, and the hemoglobin fell to 84.

It has been shown that in severe shock produced by intestinal manipulation and by trauma to a hind limb, ordinarily fluid amounting to 4 per cent of the body weight is lost into the injured part.[9] In the experiments in which the blood pressure was reduced by intestinal trauma, the amount of serum injected was usually about 2 per cent of the body weight. Similar and larger amounts of serum were given to dogs in shock from trauma to a hind limb, in one instance 6.4 per cent of the body weight. Had an attempt been made after the animals were in shock to prevent flow into the injured part, or had larger doses of serum been given, the rise in blood pressure following serum injection might have been greater and more sustained.

The experiments are too few to justify the statement that isotonic serum is more effective than gum acacia. In one hemorrhage experiment the action of acacia upon the blood pressure was like that of serum solutions. A comparison of the two experiments in which acacia was given to dogs in shock from intestinal manipulation (Chart 3) with those in which serum was given (Charts 4 and 5) to similarly shocked animals, shows that the serum in similar dosage was more effective in raising and maintaining the blood pressure.

A comparison of whole blood transfusion and serum injection has not been made. The therapeutic usefulness and practicability of serum as compared with acacia and blood can best be evaluated in the human patient.

The advantage that lyophile serum presents over whole blood is chiefly the possibility of its being readily available. As mentioned before, it can be preserved for long periods of time and is almost instantly soluble in distilled water. In the 25 human cases in which the hypertonic serum has been used intravenously, for lowering of cerebrospinal fluid pressure, doses of 100 cc. of four times concentrated solutions of serum have been attended by no evidence of untoward reactions.[4] However, in cases of nephrosis in children in which lyophile serum has been given intravenously, rather severe reactions have occurred in some instances.[15] Raudin and Stengel also have occasionally encountered reactions following the use of type specific lyophile serum in hypoproteinemic patients.[16] Reactions have also occurred in two patients in shock given pooled human serum of mixed blood type.

It is certain that the experimental data suggest that solutions of lyophile serum would be useful in the treatment of clinical traumatic shock, surgical shock, severe burns, and hemorrhage. However, pending further clinical experience it would certainly be well that lyophile serum given intravenously be administered slowly and with caution, and that pools of serum be prepared from donors of single blood type compatible with that of the recipient.

CONCLUSIONS

(1) Blood serum, preserved unaltered by freezing and desiccation (lyophile process), has been redissolved in water and injected intravenously in dogs in which the blood pressure was severely reduced by trauma to the gut or to an extremity, and by acute hemorrhage. The blood pressure was raised and maintained for at least several hours by this procedure.

(2) The immediate availability of lyophile serum, its theoretic suitability, and its action upon shocked animals, suggest its use as a valuable treatment for clinical shock and hemorrhage.

Doctors Mudd and Flosdorf, of the Department of Bacteriology of the University of Pennsylvania, have processed the serum used in these experiments. Dr. H. C. Bazett of the Department of Physiology has given the authors the facilities of his department and valuable advice. The work is an extension of that of Dr. Joseph Hughes, of the Department for Mental and Nervous Diseases of the Pennsylvania Hospital, who has expedited the work in many ways. The authors wish to express their indebtedness to these men and to Eli Lilly and Co. for providing us with solutions of acacia.

REFERENCES

[1] Elser, Thomas and Steffen: The Desiccation of Sera and Other Biological Products (Including Micro-organisms) in the Frozen State with the Preservation of the Original Qualities of Products So Treated. Jour. Immunol., **28,** 433, 1935.

[2] Flosdorf and Mudd: Procedure and Apparatus for Preservation in "Lyophile" Form of Serum and Other Biological Substances. Jour. Immunol., **29,** 389, 1935.

[3] Mudd, Flosdorf, Eagle, Stokes and McGuinness: The Preservation and Concentration of Human Serums for Clinical Use. J.A.M.A., **107,** 956, 1936.

[4] Hughes, Mudd, Strecker: Reduction of Increased Intracranial Pressure by Concentrated Human Lyophile Serum. Tr. Am. Neurol. Assn., 62nd meeting, June, 1936.

[5] Blalock: Acute Circulatory Failure as Exemplified by Shock and Hemorrhage. Surg., Gynec., and Obstet., **58,** 551, 1934.

[6] Studdiford: Severe and Fatal Reactions Following the Intravenous Use of Gum Acacia Glucose Solutions. Surg., Gynec., and Obstet., **64,** 772, 1937.

[7] Wangensteen: In discussion. ANNALS OF SURGERY, **100,** 742, 1934.

[8] Blalock, Beard and Thuss: Blood Changes with Intravenous Injections. Jour. Clin. Invest., **11,** 249, 1932.

[9] Johnson and Blalock: Effects of Loss of Whole Blood, Plasma, and Red Blood Cells. Arch. Surg., **22,** 626, 1931.

[10] Harkins: Surgical Shock from Burns, Freezing and Trauma. Colorado Med., 33, 857, 1936.

[11] Mann: Traumatic Shock. Johns Hopkins Hosp. Bull., **25,** 205, 1914.

[12] Erlanger and Gasser: Studies in Traumatic Shock. Am. Jour. Physiol., **49,** 90, 1917.

[13] Bayliss: Intravenous Injections to Replace Blood. Br. Med. Res. Com., Special Report Series, **25,** 1919.

[14] Freeman, Shaw and Snyder: The Peripheral Blood Flow in Surgical Shock. Jour. Clin. Invest., **15,** 651, 1936.

[15] Aldrich, Stokes, Killingsworth, and McGuinness: The Experience with Concentrated Human Blood Serum as a Diuretic in Nephrosis. To be published.

[16] Personal communication.

ACUTE APPENDICITIS IN COMPLETE TRANSPOSITION OF VISCERA

REPORT OF CASE WITH SYMPTOMS REFERABLE TO RIGHT SIDE MECHANISM OF PAIN IN VISCERAL DISEASE

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LEFT-SIDED appendicitis in *situs inversus viscerum* is sufficiently rare and of enough importance to warrant reporting. An instance is herewith reported of left-sided appendicitis in *situs inversus*, complicating pregnancy. Pelvic appendicitis, sometimes called left-sided appendicitis on account of the frequency of left-sided pain, and left-sided abscess with a normally located appendix, are not included in this report.

Embryology.—According to Lee,[8] up to the third month of intra-uterine life, the cecum is in the left iliac fossa alongside of the descending colon, and the ileum enters from right to left. The cecum then rotates and ascends to reach the right iliac fossa, similar to the unfolding of a fan with the mesenteric attachment as a handle. When complete the right colon crosses the duodenum in the upper abdomen and the ileum enters the cecum from left to right. Failure of migration or stoppage at any point may determine the position of the appendix. In a transposition of all viscera the appendix is normally found on the left.

Pol,[13] in 1935, found 46 cases reported of left-sided appendicitis where a *situs inversus viscerum* was present; totally in 34, and partially in 12. In only two cases was the condition chronic; the remaining showed an acute process. In more than one-half of all cases the pain was localized on the right side; naturally, in such cases a wrong diagnosis is easily made. In only seven cases was the correct diagnosis made preoperatively.

Courtney,[2] in 1931, reported a case in a female, age 21, where all clinical signs pointed to a right-sided appendicitis. A McBurney incision was made, and a hemorrhagic ovary revealed; no cecum or appendix was found in the right iliac fossa. Enlargement of the incision disclosed a diseased appendix on the left, which was removed. Exploration showed the liver and heart to be transposed. Normal recovery followed. This case has many things in common with the one to be reported here: namely, a patient admitted during the night, presenting an acute surgical condition, examined hastily for anesthesia by an intern, and heart sounds heard on the left in spite of a subsequently discovered dextrocardia, thus giving no clue to the existence of *situs inversus*.

Scopinaro,[15] in 1932, reported the case of a man, age 30, who had had

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frequent attacks of pain in the right lower quadrant. On examination there was also slight pain in the left lower quadrant, but not nearly so acute as on the right. A diagnosis of acute appendicitis was made and the patient operated upon through a Chaput (Davis) incision; search for the cecum failed to show its location, and the abdomen was closed. Roentgenologic examination, eight days later, showed the cecum and ascending colon on the left side. Six months later, through a midline incision, an adherent appendix was removed and the patient made an uneventful recovery. Scopinaro here defends the "viscerosensory" theory of pain and believes that, irrespective of the location of the appendix, pain is always felt in the right lower quadrant.

Minne,[11] in 1933, reporting a case, stresses the rarity of a true left-sided appendicitis, especially where there are absolutely no signs on the right side and where typical signs are found on the left. His case was that of a boy, age 12, who was operated upon through a McBurney incision for acute appendicitis; exploration failed to disclose the cecum in the right iliac fossa, and after enlargement of the incision the cecum and diseased appendix were found in the left iliac fossa. An appendicectomy was performed and recovery ensued. A barium enema, postoperatively, showed the cecum attached to the peritoneum at the most internal part of the left iliac fossa, behind the sigmoid; the hepatic flexure was on the right side of the spine and freely movable. However, the liver and spleen were in their normal location, hence this was not a true case of transposition of viscera.

DePol,[3] in 1933, reported a case in a man, age 35, where dextrocardia was known to exist, and in whom preoperative roentgenologic examination revealed the left-sided location of the cecum and appendix. Pain in this case was in the right iliac fossa with radiation to the left. DePol was of the opinion that the pain existed on the right on account of an "error in innervation." This is undoubtedly a very rare and questionable anatomic fact.

Mason and Baker,[10] in 1933, reported a case in a female, age 13, who was shown before operation to have a transposition of both thoracic and abdominal viscera. A left paramedian incision was, therefore, made and an acute gangrenous appendix removed. The patient made a normal recovery.

Pol,[13] in 1935, reported two cases: a girl, age 8, in whom dextrocardia was known to exist, who presented a clinical picture of right-sided appendicitis, and although a left-sided appendix was considered, a McBurney incision was made. The sigmoid was found in the right iliac fossa and the cecum was not located. A symmetrical incision made on the left disclosed a diseased appendix there which was removed, and complete recovery followed. Roentgenologic examination revealed a total, complete *situs inversus*. The second case was in a woman, age 21, with left-sided symptoms who, on operation, disclosed the cecum in the midline with a diseased appendix adherent to the sigmoid. No true *situs inversus* was present.

Votta and Robertson,[17] in 1936, reported a case in a girl, age 15, known to have dextrocardia. Repeated attacks of pain in the left iliac fossa with

nausea were the chief complaint. Further studies revealed a *situs inversus*. Through a left paramedian incision a mobile cecum was found in the left iliac fossa. The appendix was removed. The spleen and stomach were palpated on the right.

Case Report.—M. F., female, age 26, married, was brought to the Accident Ward of the Jewish Hospital, December 16, 1936, at 1:45 A.M. Service of Dr. Frank Block.

History.—Her chief complaint was pain in the right lower quadrant beginning about four hours before admission; the pain was severe and griping. She took Agarol, but obtained no relief; her physician ordered more Agarol but the pain persisted. She vomited, and obtained some relief by flexion of right thigh on abdomen. No diarrhea, but occasional frequency of urination. Patient knew she was about four months pregnant.

Physical Examination.—Temperature, 98.2° F.; pulse, 72; respiration, 20; blood pressure, 108/60. The general findings were normal, except for a slight, general muscular rigidity of the abdomen, and extreme tenderness in right iliac region. White blood cells, 21,800; polymorphonuclears, 85 per cent; lymphocytes, 15 per cent. Uranalysis, acid; sp.gr., 1.018; albumin, trace; trace of sugar; acetone, positive; 3–5 white blood cells. *Preoperative Diagnosis:* Acute suppurative appendicitis.

Operation.—Ether anesthesia. The abdomen was opened through a McBurney incision, which disclosed the ileum in the right iliac fossa, but the cecum could not be found. Almost all of the small bowel was inspected but the cecum was still not disclosed. The incision was enlarged upward, anticipating a high cecum, but such was not present. The sigmoid was found freely movable in the right iliac region, and at this point a transposition of viscera was suspected. This was confirmed when a hand, passed over the pregnant uterus into the left iliac fossa, encountered intestine which proved to be the cecum. The appendix was now easily located, found acutely inflamed, and removed through original incision in the right side. Exploration revealed the gallbladder and liver on the left side. The pathologist's report was acute catarrhal appendicitis.

Examination after operation revealed the presence of a dextrocardia, which the patient had considered too unimportant to mention.

Pain Phenomenon in Visceral Disease.—A complete physiologic presentation of the nature and localization of reflex pain in visceral disease is beyond the scope of this paper, but a few of the more acceptable theories are presented and discussed. By "referred pain" is meant that condition where the pain is localized in the somatic area which is supplied by nerves connected with the same segments of the central nervous system as those supplying the viscus. Head[5] enlarges on this definition by stating that this phenomenon always falls within the same segments through which the viscus is supplied; he divides referred pain into two groups: (1) Severe visceral pain due to angina, stones, *etc.*; (2) inflammatory visceral disease, *e.g.*, appendicitis, ulcer, *etc.*

Of the many early theories of the mechanism of referred pain such as Lang (1871), Ross (1888), Head (1889), that of Mackenzie[9] (1910) is probably the best known. In the latter theory sensory manifestations of visceral disease which are localized in somatic areas as reflex phenomena are called "viscerosensory" reflexes. These are explained on the basis of hyperirritability in the corresponding segment of the spinal cord due to exaggerated visceral stimulation, *i.e.*, the irritability of the visceral organ sets up an exaggerated flow of nerve impulses which enter the corresponding segments of the spinal cord and give rise to an "irritable focus" in which the threshold

of stimulation is reduced to such an extent that normal impulses arising in the skin and muscles give rise to pain sensations which are referred to the periphery in the somatic segments in question.

Ryle[14] referred to visceral pain as a perturbation of visceral function which may or may not be due to local organic disease; the somatic phenomenon he believes expresses a structural lesion of the wall of the viscus. Szemzo[16] modified Mackenzie's theory a bit and makes the hyperirritability of cells in the posterior horn a factor. Morley[12] does not support the theory that referred pain is from the diseased viscus but "the afferent impulses arise in the parietal peritoneum and go to the spinal cord by way of the somatic afferent fibers." However, peritoneal irritation does not always elicit referred pain—in fact, experiments have shown that pain may occur at the site of the direct stimulation.

It is fairly well accepted that referred pain is transmitted by way of visceral components of cerebrospinal nerves, and like somatic afferent fibers through the lateral divisions of the posterior spinal roots. The connections in the cord are not fully known. It is believed that impulses of visceral origin are conducted upward in the spinal cord bilaterally.

Both the theories of Mackenzie and Morley have support, and very likely both play a part in the mechanism of pain in visceral disease. As Morley[12] states: Pain or tenderness and muscle rigidity of the abdominal wall associated with inflammatory disorders in the abdomen involve two mechanisms, "peritoneocutaneous radiation" and "peritoneomuscular reflex." The assumption is that afferent impulses involved in the production of somatic pain and other somatic phenomena associated with disease of the abdominal viscera arise, not in the diseased viscus, but in the parietal peritoneum, and consequently are conducted centralwards not through visceral, but through somatic afferent nerve fibers. May it not be that early in the disease pain arises from the viscus itself and later from the peritoneal irritation? The exact moment of participation of the two structures is difficult to ascertain.

So much for the theoretic discussion of the mechanism of reflex pain in normally placed organs, but how does one explain the fact that in transposition of viscera disease of the appendix in the greater number of cases is presented as a clinical picture of right-sided appendicitis?

As mentioned previously, DePol's[3] idea of an "error in innervation" is hardly likely. Ciminata,[1] who, in 1933, made a study of pain phenomena in cases of appendices in ectopic positions, believes that as a general rule pain starts in the celiac zone regardless of the viscus and is later propagated to the visceral location. The beginning of a visceral alteration, he states, is revealed by pain in the field of the sympatheticus, while the propagation to the seat of the affected organ reveals the participation of the parietal peritoneum which, from then on, dominates the pain syndrome by way of the somatic territory. Considering the numberless individual variations found by Ciminata, generalization of this theory seems hardly possible.

Lee,[8] in 1936, offered the following explanation of the pain phenomenon;

he states that the initial pain is a true splanchnic pain referred through the mesentery of the ileum to the splanchnic plexus giving rise to epigastric pain. Later, the pain is due to peritoneal irritation of a lower group of nerves supplying the colon and peritoneum around the appendix; and finally the pain, muscle rigidity and tenderness are due to irritation of the spinal nerves in the area of the inflamed organ. How much is direct and how much is reflex seems to be a mooted question.

Albert Kuntz[7] (1937) believes that in cases of appendicitis in transposition of viscera referred phenomena ought to be localized on the right side, for even though the viscera are transposed their nerve supply remains the same. According to Kuntz any pain from an inflamed appendix located on the left side ought to be localized in the area in which pain referred from an appendix usually is localized.

SUMMARY.—(1) A brief review of literature on appendicitis in *situs inversus viscerum* is presented.

(2) A rare case of acute appendicitis in *situs inversus viscerum*, complicating pregnancy, is reported.

(3) The mechanism of pain is discussed.

(4) The author is in accordance with Kuntz, that the pain of appendicitis should be localized on the right side in *situs inversus viscerum*.

CONCLUSIONS

The author is in agreement with the theory that pain is referred along the visceral components of the cerebrospinal nerves and, like somatic nerve fibers, through the posterior spinal roots, in addition, that afferent impulses also arise in the parietal peritoneum and are referred along somatic afferent fibers.

REFERENCES

[1] Ciminata, A.: The Mechanism of Visceral Pain of Abdomen in Appendectomies under Local Anesthesia, Especially in Ectopic Positions. Riforma Med., **49**, 904, June, 1933.

[2] Courtney, A. D.: Acute Appendicitis Associated with Transposition of Viscera. Brit. Med. J., **2**, 1134, December, 1931.

[3] DePol, G.: Appendicitis on the Left Owing to "Situs Inversus Viscerum," with Clinical Localization on the Right. Gazz. d. osp., **54**, 1243, 1933.

[4] Emiliani, P.: Acute Appendicitis with Peritonitis in a Person with "Situs Inversus Viscerum." Policlinico (sez prat.) Roma, **39**, 1130, July, 1932.

[5] Head, H.: (Quoted from Kuntz.)

[6] Kuntz, Albert: The Autonomic Nervous System. 2nd Ed., Lea & Febiger, Philadelphia, 1934.

[7] Kuntz, Albert: (Personal Communication, 1937.)

[8] Lee, Q. B.: Acute Appendicitis in Abnormal Sites. Dallas Med. J., **22**, No. 3, 22–24, March, 1936.

[9] Mackenzie, J.: (Quoted from Kuntz.)

[10] Mason, J. T., and Baker, J. W.: Transposition of Viscera Associated with Acute Appendicitis. Surg. Clin. North Amer., **13**, 1439, December, 1933.

[11] Minne, J.: Appendicitis on the Left. Echo Méd. du Nord, **37**, 385, August, 1933.

[12] Morley, J.: (Quoted from Kuntz.)

[13] Pol, Z. V.: Left-Sided Appendicitis. Vestnik. Khir., **40**, 134, 1935.
[14] Ryle, J. A.: (Quoted from Kuntz.)
[15] Scopinario, A. J.: Cecocolonic Transposition—Left Appendicitis. Rev. de cir., **11**, 293, May, 1932.
[16] Szemzo, G.: (Quoted from Kuntz.)
[17] Votta, E. A., and Robertson, L. A.: Left Appendix in a Case of Visceral Transposition. Semana Med., **1**, 356, January, 1936.

THE BACTERIAL FLORA OF ACUTE PERFORATED APPENDICITIS WITH PERITONITIS

A BACTERIOLOGIC STUDY BASED UPON ONE HUNDRED CASES

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IN 1887, Pawlowsky[1] found that the contents of the intestine when injected into the peritoneal cavity produced peritonitis and death. If the same intestinal contents were rendered sterile by filtration or heating eight successive days, death would not occur. He concluded that the intestinal bacteria were of most importance in the production of peritonitis.

In 1891, Malnoz[2] stated that peritonitis of intestinal origin should not be attributed to any bacterium other than *B. coli*. In addition to *B. coli*, Fraenkel[3] (1890) described the Streptococcus, Jalaguier[4] (1892) the *Staphylococcus albus*, and Barbacci[5] (1893) the pneumococcus. Tavel and Lanz[6] (1893) presented their first bacteriologic study of peritonitis. Of 72 cases, 49 gave a positive culture; *B. coli* and the Streptococcus were the commonest organisms encountered. Perforative lesions of the small bowel were found to be more serious than those of the large bowel.

Welch and Flexner[7] (1896) found *C. welchii* in severe cases of peritonitis. Flexner[8] (1898) reported a study of 106 cases of peritonitis, and concluded that *B. coli* was of the greatest importance, overshadowing the rôle played by the Streptococcus and Staphylococcus. Craig[9] (1897) believed that appendicitis was caused chiefly by *B. coli*, since it was found in pure culture in three cases, in combination with the *Staphylococcus aureus* in two cases and with the pneumococcus in one.

Veillon and Zuber[10] (1898) emphasized the presence and importance of anaerobes in 22 cases of appendicitis, in which organisms of this type were found in 21 of them, and concluded, therefore, that anaerobic bacteria were consistently present in the pus of appendicitis, frequently predominating over *B. coli*. An anaerobic Coccus was included among the organisms described.

Kelly[11] (1899) found *B. coli* in pure culture in 69 out of 94 cases and the Streptococcus in only one. Low[12] (1900) also emphasized the presence of *B. coli*, which was found alone or in combination with other organisms in 81 per cent of 100 cases of acute appendicitis. The Streptococcus and *Diplococcus lanceolatus* were also described, but no attempt was made to identify all of the organisms which were found.

Friederich[13] (1902) reported the isolation of anaerobes from the peritoneal exudate of almost every case of perforated appendicitis which was studied. He noted the presence of anaerobic Streptococci and Bacilli of the gas gangrene

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or tetanus groups. The aerobes recovered included *B. coli*, Streptococci, Staphylococci, *B. proteus*, and *B. pyocyaneus*. Two years later Lanz and Tavel[14] published their second study, finding *B. edematis maligni* (*C. welchii*) in 49 out of 138 cases.

In 1905, Dudgeon and Sargent[15] disagreed entirely with Veillon and Zuber, Friederich, and Lanz and Tavel concerning the presence and importance of anaerobes in appendicitis. They stated that anaerobic methods of cultivation were used in many of their cases and an anaerobe (*C. welchii*) was found in only one. Their study was composed of 270 cases which included intra-abdominal hemorrhage, acute appendicitis with and without perforation, and acute appendicitis with abscess. The Staphylococcus was consistently found in these cases and frequently the *B. pyocyaneus*.

Runeberg[16] (1908) isolated *B. coli* in 14 out of 15 cases and found gram-negative, nonsporulating anaerobic Bacilli in all but three cases. Less frequently the aerobic Streptococci, anaerobic gram-positive, nonsporulating Bacilli, and anaerobic Cocci were encountered. *C. welchii* was not recovered. Of particular interest was Runeberg's finding that the serum of patients convalescent from appendicitis peritonitis showed more agglutinins to the anaerobes than to *B. coli* or the Streptococci.

Aschoff[17] (1908) studied 41 cases and found the nonhemolytic Streptococcus in 19 instances, the Enterococcus in nine, *B. coli* in 11, pneumococcus in seven, and unidentified gram-positive rods in four. *B. influenzae* was also isolated in three cases.

McWilliams[18] (1910) cultured material taken by swabbing the appendiceal serosa at time of operation. In his study of 288 cases, *B. coli* was found in pure culture in 57 per cent, *B. coli* in association with Streptococci in 19 per cent, and the Streptococcus alone in 8.3 per cent of them.

Heyde[19] (1911) in a very careful study of the anaerobic bacterial flora of appendicitis, believed *B. coli* played a minor rôle, and the small gram-negative Bacillus (*B. thetoides*) was of greater importance. Anaerobic bacteria were isolated in 100 out of 102 cases, in greater profusion than aerobes in all stages of appendicitis and peritonitis. Seventeen varieties of anaerobes were recovered, including *B. thetoides* (45 per cent), anaerobic Streptococci (20 per cent). *B. ramosus* and *B. ramasoides* (15 to 25 per cent), and *C. welchii* (15 per cent). Heyde also believed the anaerobes in peritonitis spread faster than, and frequently without, the aerobes.

Isabolinsky[20] (1914) studied 50 cases of appendicitis, both acute and chronic. *B. coli* were recovered in 43 cases, alone in 17, but usually in association with other micro-organisms. Some form of Staphylococcus was found in 21 instances and Streptococcus in seven. In addition *B. faecalis alkaligenes*, *B. pyocyaneus*, and *Diplococcus lanceolatus* were described. In no single severe case was *B. coli* alone found.

Takaki[21] (1915) reported 50 cases finding *B. coli* in pure culture in 39, *B. coli* and *Staphylococcus aureus* in six, and *B. coli* and *Streptococcus pyogenes* in five.

Brütt[22] (1923) studied 107 cases of acute appendicitis and emphasized the presence and importance of anaerobic Streptococci, which were found associated with *B. coli* in 45 instances. *B. coli* alone was recovered from 36, *B. coli* and other aerobes from eight, and other aerobes from three. The mortality was highest in those cases having anaerobic Streptococci present.

Tonio[23] (1923) believed that typical appendicitis was caused by gram-positive Diplococci and fine shaped Bacilli.

Dudgeon and Mitchiner[24] (1923) cultured *C. welchii*, *B. coli*, Streptococci, and Staphylococci from material removed from lumina of the appendices.

Bagger and Mikkelsen[25] (1924) reported *B. coli* in all but eight of a total of 160 cases. The Streptococcus, Enterococcus, and Staphylococcus were also found.

Duthie[26] (1924) isolated the Fallax Bacillus in three cases of acute gangrenous appendicitis.

Warren[27] (1925) cultured the wall, mucosa, and contents of the lumen of 66 acutely inflamed appendices. *B. coli* and *Streptococcus hemolyticus* with or without *B. coli* were the most frequently encountered organisms. The inflammatory lesion did not vary with the organism present except that it was perhaps more hemorrhagic in those infected with the *Streptococcus hemolyticus*. No anaerobes were described.

Parsons[28] (1927) summarized the cases in the literature due to *B. typhosus*, concluded they were quite rare, and reported one case of his own.

Hiegermann and Pohl[29] (1927) concluded that the clinically severe cases of appendicitis were caused mostly by the pneumococcus, Streptococcus, or *B. diphtheriae*. Vincent's Bacillus and spirochaete were also believed to play an important rôle.

Feriz[30] (1928) studied 60 cases of acute appendicitis and found the Streptococcus in pure culture in the appendix in 18 instances and in the mesenteriolum in 23. The importance of the Streptococcus in the pathogenesis of appendicitis was emphasized.

Weinberg, Prevot, Davesne, and Renard[31] (1928) studied 160 cases of acutely inflamed appendices and found anaerobes predominated in the gangrenous cases, finding *C. welchii* (33 per cent), anaerobic gram-negative Bacilli (39 per cent) and anaerobic Cocci (19 per cent). *B. coli* were cultured in 85 per cent of the cases and the Enterococcus in 30 per cent. In addition *B. proteus*, Staphylococcus, Streptococcus, *B. subtilis*, *B. mesentericus*, *B. fecalis alkaligenes*, *B. lactis aerogenes*, and *Micrococcus tetragenes* were also recovered aerobically.

Hudacsek and Kerbler[32] investigated 140 cases of acute appendicitis and described *B. influenzae*, *B. coli*, *Streptococcus hemolyticus* and *viridans*, *Staphylococcus aureus*, *Enterococcus*, *B. proteus*, *B. mesentericus*, *B. subtilis*, anaerobic Cocci and *C. welchii* in inflamed appendices. The association of influenza and appendicitis was emphasized and the *B. influenzae* was found in the appendix of one case of influenza.

Hirose[33] (1930) cultured 420 cases of acute appendicitis, but used no

special means of anaerobic cultivation. *B. coli* was found in 212 cases and some type of Streptococcus in 21. In addition, *B. fecalis alkaligenes, B. proteus, B. pyocyaneus, B. influenzae*, and Staphylococcus were encountered.

Dorsey[34] (1930) found marked similarity of Streptococci in cases of pharyngitis and appendicitis. Her cultures showed predominately *B. coli* and Streptococci (usually Diplostreptococci) and occasionally Staphylococci.

Hilgermann[35] (1931) investigated 39 acutely inflamed appendices, 36 chronic ones, and six normal ones, and found principally *B. coli*, Enterococci, and *C. welchii* in all types.

Meleney, Harvey, and Jenn[36] (1931) concerned themselves chiefly with peritoneal exudates and found most commonly *B. coli, C. welchii*, and green producing Streptococcus. Their evidence seemed to show the presence of *C. welchii* per se did not materially increase the severity of the disease.

Jennings[37] (1931) found *C. welchii* was present in the lumen of 90 per cent of the appendices, and frequently present in the local peritonitis or abscess exudate complicating appendicitis.

Gins[38] (1934) studied the bacteriologic relation between the appendix and oral cavity in eight cases, including both acute and chronic appendicitis, as well as three cases not clinically designated as to pathology. A variety of micro-organisms both aerobic and anaerobic, including *B. coli*, anaerobic Streptococci, *B. melanogenicum, C. welchii*, Leptothrix, Diplococci, anaerobic Vibriones, *B. fusiforms* and several other Bacilli were cultured. It is interesting to note that this is the only reference we were able to find in which the *B. melanogenicum* was found in appendicitis. The author recovered it from a case of chronic appendicitis, one of acute appendicitis, and one not clinically designated.

Agust Picco[39] (1936) studied the microbic flora of 21 cases of appendicitis. The aerobic flora consisted of *B. coli* predominately, Enterococci, hemolytic Streptococcus, Staphylococcus, *B. fecalis alkaligenes*, and the diphtheroid Bacillus. Only three anaerobes were found: *C. welchii*, gram-negative Cocci, and *B. ramosus.*

McDonald, Henthorne, and Thompson[40] (1937) isolated anaerobic Streptococci in 25 cases including those associated with ruptured intestine (chiefly gangrenous appendicitis), chronic pulmonary infections, and acute cerebrospinal meningitis.

At this clinic during the past two and one-half years, the bacterial flora, both aerobic and anaerobic, of the purulent peritoneal exudates secondary to acute perforated appendicitis have been studied. The cases included in this study were those of local peritonitis, general or diffuse peritonitis, and abscess. The purulent material was collected at operation and inoculated upon media immediately whenever possible. The variety of aerobic micro-organisms and their prevalence is shown in Table I.

Sixteen different species of aerobic micro-organisms were isolated from the peritoneal exudate. Only one negative aerobic culture was obtained. *B.*

coli, as has been repeatedly reported, was recovered most frequently, being found alone or in association with other aerobes in four-fifths (79) of the cases. Some form of Streptococcus was present in approximately one-half (44) of the cases. The *B. influenzae* was recovered from the exudate of a generalized peritonitis in a patient, who, immediately postoperatively, developed an acute lobar pneumonia.

TABLE I

SHOWING THE NUMBER OF SPECIES OF AEROBIC MICRO-ORGANISMS FOUND AND THEIR PREVALENCE

Micro-organism	No. of Cases
(1) *B. coli*	79
(2) Nonhemolytic Streptococcus	26
(3) Diphtheroid Bacillus	26
(4) *B. lactis aerogenes*	26
(5) Green producing Streptococcus	9
(6) *Streptococcus hemolyticus*	9
(7) *Micrococcus tetragenes*	8
(8) Sarcina	8
(9) Staphylococcus	6
(10) *B. pyocyaneus*	5
(11) *B. proteus*	5
(12) *B. subtilis*	5
(13) *B. mesentericus*	3
(14) *B. fecalis alkaligenes*	3
(15) *B. influenzae*	1
(16) Yeast	1
Negative culture	1

A pure culture of one aerobic organism was obtained in 24 instances; of two aerobes in 63, of three aerobes in ten, of four aerobes in two. The most frequent combination of aerobes was *B. coli* and *Streptococcus nonhemolyticus*. The latter frequently showed numerous diploforms as well as short chains. Seven species of aerobes were encountered in pure culture, the most frequent being *B. coli*, nonhemolytic Streptococcus, and *B. lactis aerogenes*.

TABLE II

SHOWING THE NUMBER OF DIFFERENT SPECIES OF AEROBIC MICRO-ORGANISMS ISOLATED FROM EACH CASE

No. of Species	No. of Cases
One	24
Two	63
Three	10
Four	2
Negative	1
Total	100

One case which was found to have a generalized peritonitis associated with a white blood count of 4,000 was of particular interest to us. Appendicectomy and drainage of the abdominal cavity were performed. Culture revealed a pure *Streptococcus nonhemolyticus*, no other aerobes or anaerobes being found. A very poor prognosis was given, yet the patient had a very smooth convalescence and uneventful recovery.

TABLE III

SHOWING THE INCIDENCE IN PURE CULTURE OF THE VARIOUS SPECIES OF AEROBES

Species of Micro-organisms	No. of Cases
(1) *B. coli*	14
(2) *Streptococcus nonhemolyticus*	3
(3) *B. lactis aerogenes*	3
(4) Streptococcus (green producing)	1
(5) *B. subtilis*	1
(6) *B. fecalis alkaligenes*	1
(7) *B. proteus*	1
Total	24

Anaerobic micro-organisms were cultivated in 96 of the 100 cases of peritonitis studied. Their cultivation, isolation, and identification were very difficult, and at times their identification was impossible. The unidentified bacteria included gram-negative Diplococci, various forms of gram-negative

TABLE IV

SHOWING RESULTS OF THE ANAEROBIC CULTIVATION OF THE PERITONEAL EXUDATE

Species of Anaerobic Bacteria	No. of Cases	Percentage of Total Positive Cultures
(1) *B. melanogenicum*	89	92.7%
(2) Nonhemolytic Streptococcus	57	59.3%
(3) Hemolytic Streptococcus	7	7.2%
(4) Gram-negative Diplococcus	18	18.7%
(5) *B. thetoides*	11	11.4%
(6) Unidentified gram-negative Bacilli	10	10.4%
(7) *Streptobacterium fetidus*	9	9.3%
(8) Unidentified gram-positive Bacilli	7	7.2%
(9) Staphylococcus	6	6.2%
(10) *Clostridium aerofetidus*	5	5.2%
(11) *B. pseudodiphtheriae*	4	4.1%
(12) *Clostridium sporogenes*	4	4.1%
(13) Gram-positive Diplococci	3	3.1%
(14) *Clostridium putrificus*	3	3.1%
(15) Gram-positive Streptobacillus	2	2.0%
(16) *B. bifidis*	2	2.0%
(17) Gram-positive Bacillus producing red colonies	2	2.0%
(18) *Clostridium welchii*	1	1.0%

Bacilli, gram-positive Bacilli (some of which produced red colonies), gram-positive Diplococci, and gram-positive Streptobacilli. Thus at least 18 different species of anaerobic bacteria were recovered from the peritonitis exudates.

It is of especial significance to note the fact that the *B. melanogenicum* was cultured from the peritonitis exudate of 89 cases, or 92.7 per cent of the total number of cases yielding positive anaerobic cultures. As far as we have been able to determine, this Bacterium has never been described before in the purulent peritoneal exudate secondary to acute perforated appendicitis. Gins,[38] in 1934, made the only reference to the *B. melanogenicum* occurring in appendicitis, which we have been able to find, having recovered this organism in three cases—one of acute appendicitis, one of chronic appendicitis, and one whose pathology was not designated.

Of almost equal interest is the presence of anaerobic Streptococci in 64 cases (66.6 per cent of the positive anaerobic cultures). These Streptococci in almost every instance grew in close symbiosis with the *B. melanogenicum*, and were separated from the latter with extreme difficulty. Anaerobic Streptococci have been previously described in peritonitis by Veillon and Zuber, Runeberg, Heyde, Brütt, Weinberg, *et al.*, Friederich, Hudacsek and Kerbler, Gins, and McDonald, Henthorne, and Thompson.[40]

Members of the Clostridium group were recovered in only 13.5 per cent of the cases. This was quite surprising in view of the frequent reports of the prevalence of members of this group, especially *C. welchii*, in acute appendicitis peritonitis.

B. thetoides was isolated in 11.4 per cent of the cases but much less frequently than was reported by Heyde, who found this organism in 45 per cent of his cases.

The gram-negative Diplococci, which was found in 18.7 per cent of the cases yielding positive cultures, were very small gram-negative organisms which resembled the *Diplococcus reniformis*.

TABLE V

SHOWING THE NUMBER OF DIFFERENT SPECIES OF ANAEROBIC MICRO-ORGANISMS ISOLATED FROM EACH CASE

No. of Species	No. of Cases
One	5
Two	42
Three	45
Four	4
Negative	4
Total	100

Two species of anaerobes were recovered from each of 42 cases, and three from each of 45 cases. Thus, in 91 cases more than one anaerobic bacteria

was cultured. Comparison of Tables II and V shows that the average number of different species of anaerobes per given case exceeds that of the aerobes. This is in agreement with the findings of Veillon and Zuber, Runeberg and Heyde, who found the anaerobes were frequently predominant. In 69 cases the *B. melanogenicum* was found in very close symbiosis with some form of anaerobic Coccus.

In considering the total number of different species of both aerobic and anaerobic micro-organisms found in the peritonitis exudate, it is found that three or more species were recovered from 96 of the 100 cases, and five or more in 50 of the cases (Table VI). Every peritonitis exudate which was investigated bacteriologically yielded at least one Bacterium and in no instance was an entirely negative culture obtained. The average number of species per case was 4.28.

TABLE VI

SHOWING THE NUMBER OF SPECIES (BOTH AEROBIC AND ANAEROBIC) FOUND IN EACH CASE

No. of Species	No. of Cases
One	3
Two	3
Three	17
Four	27
Five	41
Six	8
Seven	1
Total	100

These findings show the bacterial flora of peritonitis secondary to acute

TABLE VII

SHOWING THE INCIDENCE OF THE VARIOUS ORGANISMS IN THE SIX FATAL CASES

Micro-organism	No. of Cases
B. coli	6
B. melanogenicum	6
Anaerobic Streptococci	6
Streptobacterium fetidum	2
B. proteus	1
Streptococcus (green producing)	1
Staphylococcus	1
Streptococcus (hemolytic)	1
Streptococcus (nonhemolytic)	1
B. influenzae	1
Yeast	1
B. thetoides	1
C. welchii	1
Unidentified gram-positive rod	1

perforated appendicitis to be more complex and bizarre than previously believed.

In comparing the flora of the fatal and nonfatal cases, little difference is found in the type of species present. The *B. coli, B. melanogenicum,* and anaerobic Streptococcus were recovered from each of the six fatal cases.

Wishing to determine whether or not the numerous bacteria were present in only the immediate peritoneal exudate or in the delayed secondary and metastatic abscesses as well, the flora of all such complicating abscesses was also investigated.

CASE 1

Generalized peritonitis
- *B. coli*
- Hemolytic Streptococcus
- Diphtheroid Bacillus
- *B. melanogenicum*
- Anaerobic Streptococcus
- *Streptobacterium fetidum*

Metastatic lung abscess
- *B. coli*
- Hemolytic Streptococcus
- *B. melanogenicum*
- Anaerobic Streptococcus

CASE 2

Appendiceal abscess
- *B. coli*
- Nonhemolytic Streptococcus
- Diphtheroid Bacillus
- *B. melanogenicum*
- Anaerobic Streptococcus
- Unidentified gram-positive rod (anaerobic)

Secondary intra-abdominal abscess
- *B. coli*
- Nonhemolytic Streptococcus
- *B. melanogenicum*
- Anaerobic Streptococcus
- Unidentified gram-positive rod (anaerobic)

Encapsulated (pleural) empyema
- *B. coli*
- Nonhemolytic Streptococcus
- *B. melanogenicum*
- Anaerobic Streptococcus

CASE 3

Generalized peritonitis
- *B. coli*
- Hemolytic Streptococcus
- *B. melanogenicum*
- Anaerobic Streptococcus
- Unidentified gram-negative rod (anaerobic)

Subphrenic abscess
B. coli
Hemolytic Streptococcus
B. melanogenicum
Anaerobic Streptococcus
Unidentified gram-negative Bacillus (anaerobic)

CASE 4

Appendiceal abscess
B. coli
Staphylococcus
B. melanogenicum
B. thetoides
Anaerobic Streptococcus (hemolytic)
Metastatic brain abscess
Hemolytic Streptococcus
Staphylococcus
B. melanogenicum
Anaerobic Streptococcus (hemolytic)
B. thetoides

CASE 5

Generalized peritonitis
B. coli
B. pyocyaneus
B. melanogenicum
B. thetoides
Anaerobic Streptococcus
Subphrenic abscess
B. coli
B. pyocyaneus
B. melanogenicum
Anaerobic Streptococcus
B. thetoides

CASE 6

Local peritonitis
B. lactis aerogenes
B. pyocyaneus
C. aerofetidus
Anaerobic Streptococcus
B. melanogenicum
Subcutaneous appendicectomy wound abscess, appearing three months postoperatively
B. lactis aerogenes
B. melanogenicum
Anaerobic Streptococcus

Comparing the flora of the original peritoneal exudate culture with that of its secondary and metastatic abscess complications, we found essentially the same organisms in each instance. It was of particular interest to note the almost identical flora of an appendiceal abscess as compared with a metastatic brain abscess developing six weeks after operation. These findings indicate that the peritonitis resulting from a perforated appendix, and its

purulent complications as well, are mixed infections, and are not due to single organisms.

Discussion.—It is not surprising that the bacterial flora found in the peritoneal exudate resulting from a perforated appendix is so complex and varied if we consider that the ileocecal region of the intestines is the culture medium and incubator in which bacterial growth exceeds in both intensity and complexity, that of any known medium (Kendall[41]). The relative slowness with which food passes through the intestines at this lower level favors continued bacterial growth. The alkaline intestinal contents rich in proteins and carbohydrates in solution are particularly suited for bacterial life. The total amount of bacteria that finally appear in the feces according to Strasburger[42, 43] and Steele[44] may reach the enormous figure of 38 per cent of the total bulk, although it has been estimated that 90 per cent of these bacteria are dead or so attenuated that they are incapable of cultivation.

Consequently any perforative lesion in the region of the appendix or cecum must necessarily result in the contamination of the peritoneal cavity by a large number and variety of organisms resident in that region of the intestine at the time of perforation. That many of these bacteria grow prolifically within the peritoneal cavity has been proven. When cultured these organisms grow best in close association or symbiosis with each other.

We are not prepared to say whether all the organisms cultured from the peritoneal exudates came from the intestinal lumen or whether some were carried to the appendix by the blood stream.

It is difficult to explain why the *B. melanogenicum* has not been described before in appendicitis peritonitis, especially since it can be recovered so frequently from the feces. Its importance alone or in symbiosis with other bacteria, particularly anaerobic Streptococci, is not known.

CONCLUSIONS

(1) One hundred cases of acute perforated appendicitis with abscess, local or general peritonitis, were studied bacteriologically, using both aerobic and anaerobic methods of cultivation.

(2) The bacterial flora of these cases presented a very complicated and bizarre picture, contrary to the frequently accepted idea that *B. coli* and/or the streptococcus alone are the etiologic agents of appendicitis peritonitis.

(3) This bacterial flora is, at least to a large degree, composed of microorganisms which have been isolated from the intestinal tract of man.

(4) Essentially the same organisms can be isolated from associated secondary and metastatic abscesses in remote areas of the body.

(5) The presence of *B. melanogenicum*, which was found in 92.7 per cent of the cases, is described for the first time, to the best of our present knowledge, in appendicitis peritonitis. The frequent association of the *B. melanogenicum* and anaerobic Streptococci is emphasized.

(6) The more clinically severe cases of acute perforated appendicitis occurred most frequently in those cases having five or more infecting micro-

organisms. No case from which only one Bacterium was recovered terminated fatally.

(7) It has been impossible to predict the course of appendicitis peritonitis from the type of bacteria isolated from any given case.

BIBLIOGRAPHY

[1] Pawlowsky, A. D.: Centralbl. f. chir., **14,** 881, 1887.
[2] Malnoz, E.: Arch. de Méd. exper. et d'anat. path., **3,** 593, 1891.
[3] Fraenkel, E.: München med. Wchnschr., **37,** 23, 1890.
[4] Jalaguier: Bull. et Mem. Soc. de Chir. de Paris, **18,** 390, 1892.
[5] Barbacci, O.: Centralbl. f. Allg. Path. u. Path. Anat., **4,** 768, 1893.
[6] Tavel, E., and Lanz, O.: Mitt. a. d. Klin. u. Med. Inst. d. Schweitz, **1,** 1, 1893.
[7] Welch, W. H., and Flexner, S.: Jour. Exper. Med., **1,** 5, 1896.
[8] Flexner, S.: Phila. Med. Jour., **2,** 1019, 1898.
[9] Craig, C. F.: New Eng. Med. Monthly, **16,** 407–417, 1897.
[10] Veillon A., and Zuber, A.: Arch d. Med. Exper. d'anat. path., **10,** 517, 1898.
[11] Kelly, A. O. J.: Phila. Med. Jour., **4,** 928, 983, 1032, 1899.
[12] Low, H. C.: Med. and Surg. Rep. Boston City Hosp., **11,** 173–179, 1900.
[13] Friederich: Arch. f. klin. Chir., **68,** 524, 1902.
[14] Lanz, O., and Tavel, E.: Rev. de Chir., **30,** 45, 215, 1904.
[15] Dudgeon, L. S., and Sargent, P. W. G.: Lancet, **1,** 473, 548, 617, 1905.
[16] Runeberg, B.: Arb. a. d. Path. Inst. d. Univ. Helsinfors, **1,** 271, 1908.
[17] Aschoff, L.: Verhandl. d. deutsch. path. Gesellsch., **11,** 313–318, 1908.
[18] McWilliams, C. A.: ANNALS OF SURGERY, **61,** 909, 1910.
[19] Heyde, M.: Beitr. z. klin. Chir., **76,** 1, 1911.
[20] Isabolinsky, M.: Centralbl. f. Bakt., **73,** 488, 1914.
[21] Takaki, Y.: Sei-I-Kwai Med. Jour., **33,** 45, 1914.
[22] Brütt, H.: Beitr. z. klin. Chir., **129,** 175–185, 1923.
[23] Tonio, A.: Schweiz. med. Wchnschr., **53,** 947, October 11, 1923.
[24] Dudgeon L. S., and Mitchiner, P. H.: Brit. Jour. Surg., **11,** 676–689, 1924.
[25] Bagger, S. W., and Mikkelsen, O.: (Abst.) J.A.M.A., **83,** 314, July 26, 1924.
[26] Duthie, G. M.: Abst. J.A.M.A., **83,** 719, August 30, 1924.
[27] Warren, Shields: Am. Jour. Path., **1,** 241, 1925.
[28] Parsons, W. H.: New Orleans Med. and Surg. Jour., **79,** 893–896, June, 1927.
[29] Hiegermann and Pohl: München. med. Wchnschr., **74,** 1700, October 7, 1927.
[30] Feriz, H.: Deutsche med. Wchnschr., **54,** 1970, November, 1928.
[31] Weinberg, M., Prevot, A. R., Davesne, J., and Renard, C.: Ann. de L'Inst. Pasteur, **42,** 1167, 1928.
[32] Hudacsek, E., and Kerbler, K.: Arch. f. klin. Chir., **161,** 540, 1930.
[33] Hirose, H., and Tohnkn: Jour. Exper. Med., **15,** 524–536, June, 1930.
[34] Dorsey, A. H. E.: Surg., Gynec., and Obstet., **50,** 562, 1930.
[35] Hilgermann, R.: Beitr. z. klin. Chir., **152,** 323, 1931.
[36] Meleney, F., Harvey, H. D., and Jenn, H. Z.: Arch. Surg., **22,** 1, January, 1931.
[37] Jennings, J. E.: ANNALS OF SURGERY, **93,** 828–836, 1931.
[38] Gins, H. A.: Deutsche med. Wchnschr., **60,** 1463–1465, September 28, 1934.
[39] Picco, Augusto: Arch. Per. Le Med., **62,** 241–259, 1936.
[40] McDonald, J., Henthorne, J., and Thompson, Luther: Arch. Path., **23,** 230, February, 1937.
[41] Kendall, A. I.: Bacteriology, General, Path. and Intestinal, Page 579, Lea & Febiger, 1916.
[42] Strasburger, J.: Ztschr. f. klin. Med., **44,** 5–6, 1902; **46,** 413, 1902.
[43] Idem: Ztschr. f. klin. Med., **48,** 5–6, 1903; **48,** 491, 1903.
[44] Steele, J. D.: J.A.M.A., **49,** 647, August 24, 1907.

THE RARE INCIDENCE OF ACUTE APPENDICITIS RESULTING FROM EXTERNAL TRAUMA

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THE correct evaluation of external trauma in acute appendicitis is important. Traumatic influences should be judged only on a very critical basis. This is purely a medical problem from the legal viewpoint. Court decisions rest entirely upon expert testimony, and the surgeon who appears as a witness should do so for the purpose of throwing light upon a subject of which the court is ignorant. These decisions are influenced by the attitude of expert witnesses who should be enlightened, frank and helpful. The court expects integrity, and looks to the physician for real information. The broadened conception of the Compensation Law takes cognizance of the secondary, aggravating or contributing effects of injury upon disease. Decisions should rest upon proven facts, not theoretic opinions. Evidence should be overwhelming and leave no doubt. This study was prompted in order to determine the relation of external trauma to the occurrence of acute appendicitis, and was based upon: (1) nine personal cases; (2) a review of continental and American literature; (3) 48 litigated cases; and (4) a survey of current surgical thought.*

It is conceded that the appendix is not immune to injury. It is believed, however, that the majority of cases reported as traumatic appendicitis are misnamed. In the evaluation of traumatic influence, five essentials must be united and correlated: *i.e.*, (1) the history; (2) the force; (3) the mechanism; (4) elapsed time between the accident; the development of the disease and operation; (5) the pathology demonstrated at operation.

The History.—The fact that appendicitis may have antedated the accident may be withheld by the patient, in an attempt to place the entire blame upon the injury. It is stressed, therefore, that the history in such cases may be entirely valueless. In several of my cases, an accident was first blamed, and later when the patient entered the hospital for operation, no mention was made of the accident, to the intern who took the history. The previous state of health in Kelly's series is not mentioned in 35 cases. It was reported "good" in 13. It is noted that a history of previous attacks was obtained in only two cases.

The Force.—The application of blunt force, over the appendix region, run-over accidents of crushing violence or pinioning the abdomen against an immovable object with sudden disturbance of intra-abdominal pressure, are direct types. Indirect forms of violence of less significance are falls upon regions other

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than the abdomen, prolonged exertion of dancing, skipping rope, bicycle riding, playing golf or tennis. Lifting heavy objects may be alleged to be the cause in industry. Exertion was mentioned in 20 of Kelly's cases, falls in six and direct blows in 24. In no instance was there any external evidence of injury to the abdominal wall.

Mechanism.—Increased intra-abdominal pressure is involved in direct injury. Sudden muscular action, involving strain, is blamed in indirect. The direct force, when applied to the abdomen, is transmitted through the wall, to

TABLE I

INCIDENCE

Reported by	Cases	History of Trauma	Percentage	Children	Cases	Percentage
Speed	313	3	0.9	313	3	0.95
Ray	600	3	0.5	....	..	....
Borchard, Opitz	150	3	2.0	....	..	....
Block	....	..	2.0	....	..	....
Sewall	....	..	75–80	....	..	....
Van Neuman	....	..	6.6	....	..	....
Steiner	400	4	1.0	....	..	....
Wilhelm	940	3	0.3	....	..	....
Bissell	....	..	4.0	....	..	....
Ochsner	3,300	9	0.2	....	..	....
Hawkes, Stewart	4,300	3	0.7	....	..	....
Maes	1,260	6	0.4	1,260	6	0.47
Levai	....	..	0.85	....	..	....
Fox, Zerbe	1,700	1	0.14	....	..	....
Ebner	....	..	0.8	....	..	....
Hawkins	....	..	8.4	....	..	....
Sonnenberg	....	..	2.0	....	..	....
Nudeleman	....	..	1.2	....	..	....
Stern	533	13	2.0	....	..	....
Totals	13,496	48	0.3	1,573	9	0.57

the contents beneath, consisting of gaseous, fluid, semifluid, and solid media, subject to displacement and pressure changes. Fixed structures are subject to greater stress than those loosely attached. Pressure within the appendix may be increased by any force which decreases intra-abdominal space. This force must be suddenly exerted. A direct blow suddenly throws the abdominal muscles into a state of violent contraction. Blows or falls on the back, or back injuries, usually have no relationship to appendicitis, because of the large powerful muscles which form the posterior abdominal wall. The state of the abdominal muscles and the thickness of the wall at the time of impact are important considerations. An appendix is more readily injured when the muscles are flaccid than when rigid. In a recent personal communication, Dr. Robert T. Morris cited the case of a farrier who was kicked in the abdomen by a horse. He states: "At operation, the blow apparently lifted the cecum

out of position. When it returned, the appendix became twisted upon its mesentery and both lumen and blood supply were obstructed." Deep, rough palpation of a thin, relaxed abdominal wall, in the course of examination by the surgeon, may arouse a dormant appendix. It is necessary to consider separately the intimate modus operandi of trauma upon an already diseased appendix. Under such conditions a direct blow or crushing injury delivered over the cecum may cause a true traumatic lesion or forcible expulsion of gas and fecal contents into the organ. In this connection we must consider the rôle of the fecalith. Medical opinion concedes that the presence of a fecal concretion or foreign body is definite evidence of disease, though such an appendix may remain clinically quiescent. In the potential obstructive type caused by fecaliths, the luminal pressure increases following a blow upon the abdomen. Minute fissures in the mucosa or lacerations may occur permitting invasion by bacteria into the submucous coats. These conditions furnish the factors necessary for complete obstruction, attended with stasis, inadequate drainage, defective circulation, and the final stage of gangrene, and spontaneous perforation. The mechanism of the blow delivered over the cecum is much the same as that which operates in the case of a cathartic. The effect is the same sudden peristaltic action, the one being external, the other internal. The injection of opaque media under high pressure, for the purpose of roentgenologic visualization of the colon and appendix, may result in such a degree of inflation as to induce a recurrent appendicitis.

As to indirect trauma, Byron Robinson advanced the theory that action of the psoas muscle may act as a mechanical factor in causing appendicitis, in those cases in which the organ lies upon the muscle. Powerful contractions of this muscle, and perhaps the iliacus, according to this author, irritate the appendix, causing adhesions, bands, angulations, kinks or obstructions. It is, therefore, conceivable that an appendix already handicapped by such pathology might be further aroused when firmly adherent to these muscles, by repeated acute flexion of the thigh upon the trunk as in bicycling. Kelly reports the case of a boy who was turned upside down in play, and whose appendix was found to have been freshly penetrated by a pin. There were no adhesions. The pin had remained innocuous until the unusual sudden change in posture had shifted its position. This would appear to be an example of both indirect external trauma, and direct internal trauma operating upon a diseased appendix. The mechanism of indirect force, strain, or violent effort may be attributed to action of the abdominal muscles, as in the case of a clerk, also reported by Kelly, who attempted to lift a heavy object above his head, while standing on a ladder which shifted its position. He was forced to suddenly exert himself, causing a violent strain on the abdominal muscles, resulting in acute pain, which persisted for ten days, when he died. Autopsy revealed general peritonitis from a ruptured appendiceal abscess. E. Staude reported typical symptoms developing in a boy who had scrubbed a floor. This occupation involved rotating movements of the trunk and sudden assumption of the erect posture from a crouching position. At operation, a free appendix was located, with a very long

mesentery which had undergone 360° of torsion. It was readily untwisted, and was the seat of edema, punctuate hemorrhages, and filled to capacity with feces. Similar cases are described by Oesch, Ringel and Routier. The trauma of transporting a case of advanced appendicitis, in an ambulance over rough roads, may precipitate a rupture. Contortions, as the case of the famous Houdini, may be held liable for rupture of an appendiceal abscess (DeWitt Stetten).

Finally, the expulsion of cecal contents into the appendix is the common explanation of the mechanism inducing many so-called cases of acute primary traumatic appendicitis following a direct blow, without a prior history of appendicitis, *without evidence of prior pathology or genuine traumatic pathology at operation.* It assumes a previously normal appendix. It is a theory which cannot be conceded.

Elapsed Interval between Injury and Symptoms.—If the trauma has forced the patient to stop work at once and he has since had continuous trouble, its importance has to be recognized. Pain is a source of immediate complaint within a few hours. It has been stated that if symptoms develop after 48 hours, responsibility for the accident may be rejected. The longest interval admissible, between trauma and first manifestations, is 48 hours, according to Bruening. Jottkowitz acknowledges an interval of two or three days if there has been a bridging of symptoms. A study of the elapsed time between the injury and development of symptoms in Kelly's cases shows that 42 cases developed within 48 hours.

Pathology.—Genuine traumatic pathology is very rarely demonstrable in the appendix, when compared with the frequency with which contusion, hematoma, laceration, and rupture or perforation are encountered in other abdominal organs. These lesions should be designated as such, and not as traumatic appendicitis, unless it has been proven beyond doubt microscopically that the necessary inflammatory reaction is a sequence. Gutzeit, Oesch, Fox and Zerbe have each encountered a case in which true traumatic lesions were demonstrated at immediate operation, and which on microscopic examination showed no appendicitis. Table II shows examples of true lesions. Potential morbid conditions which make for ready further bacterial invasion after direct abdominal injury are angulations, bands, adhesions and a shortened mesentery. Conditions within the appendix are an incompetent Gerlach valve action, strictures, concretions and foreign bodies. It is conceded that many and varied are the already existing lesions which may be lighted up by trauma. It is conceivable that certain definite bands or adhesions may be the seat of actual laceration, or proof may be present at immediate operation that an abscess was actually ruptured by a direct blow or by exertion of indirect violence.

Brunig has made a comparative study of concretions in cases in which no trauma figured in the history and in cases in which trauma appeared. In nontraumatic histories, concretions were found in 35 per cent and in traumatic

histories in 65 per cent. This has not been confirmed. The local lesions, according to Desmarest, are, in the majority of cases, due to a partial gangrene of the appendix. This observation was also made by Kelly. In 37 of his 50 cases, the appendix was gangrenous or perforated. In the majority, the lesion was of an advanced obstructive type. A fecalith was found in 30 cases. There were no true traumatic lesions.

The final diagnosis should be made microscopically in conjunction with the clinical history. This necessity is shown in a case reported by K. A. Bartels of a farmer, age 27, who was kicked by a calf. Operation disclosed an acutely inflamed appendix, fresh adhesions, fibrinous exudate and signs of hemorrhage—all indicative of recent pathology. The microscopic examination, however, revealed a carcinoid condition. Maes in commenting upon this case, states: "This surely cannot be classified as traumatic appendicitis."

TABLE II

TRAUMATIC LESIONS

Traumatic lesions without superimposed appendicitis (diagnosed microscopically)	3
Appendix	
(1) Perforation	2
(2) Laceration	3
(3) Hemorrhagic suffusion, subserous, diffuse, local ecchymosis	3
(4) Avulsion of serosa—also adjacent ileum and cecum	2
Mesentery	
(1) Laceration, rupture of appendicular artery	3
(2) Hematoma, subserous	2
(3) Ecchymosis, also adjacent ileum	1
Appendix and Mesentery	
Hemorrhage into	1
Ascending Colon	
Rupture terminal branch ileocolic artery	1
Cecum and Ileocecal region	
Ecchymosis	2
Total	23

It cannot. It does, however, present a typical example of acute pathology resulting from trauma, superimposed upon a chronic lesion, and constitutes definite evidence of aggravation. It is urged that a very careful examination of the surrounding parts be made by the surgeon at operation and of the specimen by the pathologist in potential medicolegal cases. Is the pathology exclusively recent or old or is there fresh pathology superimposed upon a chronic lesion? This determination is essential. The presence or absence of a fecalith may be a highly significant factor. The appendix should be split and examined for strictures, fecaliths and foreign bodies. Adhesions should be particularly noted, whether old or recent. Measurements should be taken and the specimen preserved as an exhibit. Fecaliths indicate old pathology and should always be crushed to determine the character of the nucleus.

PERSONALLY OBSERVED CASES IN WHICH TRAUMA WAS A FACTOR.—Nine cases have been studied, of which eight were adult males. Their ages varied

from 12 to 46. The interval between the accident and the symptoms varied from immediate development to six months. Operation was performed within a few hours in three, 23 days in three, three months in two and after six months in one. Four cases gave an antecedent history of appendicitis. Seven followed indirect injury. Hospital records failed to indicate any history of injury in four, though claims for injury were made to insurance companies which had to be evaluated and defended. Critical analyses submitted to the defendants' attorneys in three cases were successful in having the claims withdrawn. In one instance there was an ecchymosis in the right lower quadrant. There was no genuine traumatic pathology in the appendix or its vicinity in any case. Two were chronic lesions, one with a fecalith, one rectrocecal and kinked. One was chronic (acknowledged dormant) with an acute superimposed catarrhal appendicitis. Six were acute lesions, of which four were gangrenous. One was acutely inflamed and distended. One was much elongated, taut and adherent.

Five of the cases were tried. Two were based upon aggravation and three upon origination. Two were compensation cases. Both were won by the plaintiff. One was based upon origination due to indirect violence, which was finally decided on appeal, and one was based upon aggravation due to a direct blow. There were four verdicts for the plaintiff. Two of these were tried upon the basis of origination and two upon aggravation. One was the result of an appeal. One verdict, for $11,000, was obtained for one plaintiff upon the basis of aggravation by a direct blow, in which a latent appendicitis was thought to exist without symptoms; showing at operation, 23 days after the accident, an acute catarrhal, retrocecal appendix with old, dense adhesions. There were two death claims. One was not pressed. In the other—the one suit which resulted in a verdict for the defendant—appendicitis followed an alleged back injury six months after the accident, when operation disclosed a gangrenous, perforative appendicitis with peritonitis. In the four cases with prior attacks, no claim was made in one, and in two the claims were dropped, because the hospital record, later, failed to support a history of an injury which had been previously reported to the insurance carrier. One death claim was also dropped because of the absence of a history of injury on the hospital record. Of four verdicts for the plaintiff, direct violence occurred in two, indirect in two (Table III).

Collective Review.—Fifty cases reported as primary traumatic appendicitis without previous attacks or prior evidence of disease at operation have been submitted in personal communications and collected from current literature. Scrutinized under strict criteria, only about 20 escape exclusion. Three were genuine traumatic lesions in which microscopic examination failed to reveal appendicitis and have been ruled out. The remaining were reported on a primary basis, without evidence of trauma at operation, and only the usual inflammatory changes to support the author's contention. In these, records are incomplete. The time element criterion has not always been fulfilled. In others operation had been long delayed. Acceptance upon a

TABLE III

SYNOPSIS OF NINE PERSONALLY OBSERVED CASES IN WHICH TRAUMA WAS A FACTOR

Age	Sex	Interval between Accident, Symptoms and Operation	Antecedent History of Appendicitis	Violence	Basis of Claim	Lesion	Result of Litigation
12.....	Male	24 hours	Present	Indirect	None	Gangrenous, fecalith	
18.....	Male	20 days	None	Indirect	Origination	Gangrenous	$2,100 for plaintiff
36.....	Male	Immediately, operation in 3 months	Present	Direct	Aggravation, also Tbc.	Chronic, fecalith	25 per cent of total permanent for petitioner
46.....	Male	24 hours	Present	Indirect	Aggravation	Acute, elongated, taut, adherent	Claim dropped
30.....	Male	Immediately, operation in 23 days	None	Direct	Aggravation	Retrocecal, acute catarrhal, old adhesions	$11,000 for plaintiff
35.....	Male	6 months	None	Indirect	Origination, two counts	Retrocecal, angulated, gangrenous	(1) For def. in case of appendicitis, death claim. (2) $30,000 for plaintiff in back injury
46.....	Male	3 months	None	Indirect	Origination	Gangrenous	Death claim dropped
34.....	Male	7 hours	None	Indirect	Origination	Acute, distended	Verdict for plaintiff on appeal
31.....	Female	Immediately, operation in 10 days	Present	Indirect	Aggravation	Retrocecal, chronic, kinked	Claim dropped

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primary basis can only be speculative and assumes the expulsion of cecal contents into a normal appendix as the determining factor.

Litigated Cases.—Forty-eight operative cases, claiming that trauma produced appendicitis, have been studied. There were 24 verdicts for the plaintiff and 24 cases for the defendant. Six cases were appealed. Three decisions for the plaintiff were finally reversed. One was sustained. One decision in favor of the defendant was later reversed and one in favor of the defendant was sustained. In several cases, claims were allowed by insurance companies without question (two blow cases and one strain case). One was a ruptured appendix without previous symptoms or preexisting pathology. A second is said to have shown evidence of contusion and laceration of the tissues surrounding the appendix. In a third case, a large corporation accepted the claim that appendicitis developed as the result of chasing a runaway horse. The animal was caught and personal injury to bystanders thus averted. This claim was possibly settled as a reward for timely action. Of 24 cases, in which the character of the injury was specific, 12 were due to direct and 12 to indirect violence. There were eight death claims, all of which recovered damages, except one strain case. There were 18 verdicts for the plaintiff and six for the defendant. In 12 indirect injuries, there were eight verdicts for the plaintiff. In the 12 direct injuries, there were ten verdicts for the plaintiff.

Summary.—(1) Appendicitis has been held a compensable injury by the courts; based upon both origination and aggravation, the result of direct as well as indirect violence. (2) Less doubt exists as to casual connection in cases of aggravation than in origination, and in those cases following direct violence than in those following indirect violence. (3) Verdicts in general regardless of whether cases of aggravation or origination, negligence actions or compensation cases, are equally divided between plaintiff and defendant. (4) In cases of direct injury, the courts have favored the plaintiff in the ratio of five to one. (5) In cases of indirect injury verdicts in favor of the plaintiff two to one.

Survey of Current Surgical Thought.—In a survey of the opinions of distinguished foreign surgeons, only Sir Arbuthnot Lane believes that external trauma has no relationship whatsoever to appendicitis. Professor Lambert Rogers, of the Surgical Unit, Welsh National School of Medicine, Cardiff, is the only one who favors a primary relationship. There are six who contend that external trauma is purely secondary and may influence only an appendix already diseased. They are Sir William Wheeler, Sir G. Lenthal Cheattle, Sir W. Sampson Handley, Mr. Robert V. Dolbey, all of London, Professor Archibald Young of the University of Glasgow, and Sir David P. D. Wilkie of Edinburgh, though Sir David states in his letter: "It is quite possible that an obstruction (concretion) might be primary by some form of external violence applied to the abdomen." Lord Moynihan, of Leeds, stated he had "no experience in traumatic appendicitis," and offers no opinion with respect to the influence of injury. Professor F. De Quervain, Director

of the Surgical Clinic, University of Bern, Switzerland, expresses a sane and lucid opinion: "One should express himself with great caution about the relationship of external trauma to appendicitis because one never knows what was the condition of the appendix prior to the injury. One finds, so often, slight inflammatory changes even in normal looking appendices on histologic examination that one may inquire how many appendices remain at all normal after reaching maturity. The normal appendix is, as a rule, better protected from traumatic influences than any other part of the G. I. tract, and no part is less inclined to be damaged by trauma than the appendix; this is based on its anatomic structure. When a heavy local contusion really causes damage to the ileocecal region, the participation of the appendix is then of less importance. In many thousands of cases of acute and subacute appendicitis, I have never observed anything which would throw any light on its traumatic origin. It is a different matter when a latent, or really existent appendicitis, is aggravated by a trauma. Even such occurrences take place so seldom that the physician should be very careful in his final opinion. One must add to it the possibility of rupture of an appendicular empyema, or the development of a diffuse peritonitis from a localized periappendicular abscess. In my long clinical observation of 26 years I cannot remember seeing such a case, but I cannot deny its possible occurrence."

Of five opinions expressed by our Canadian colleagues, all accept a definite relationship between trauma and appendicitis. Of these Dr. Stuart D. Gordon, of Toronto, and Dr. L. S. Mackid, of Alberta, accept trauma as a primary factor. Dr. W. A. Lincoln, of the Calgary Associate Clinic, Alberta, Dr. Campbell B. Keenan and Dr. E. W. Archibald, of Montreal, favor acceptance of trauma only as a contributory factor. Polls have been made of three surgical societies: 16 per cent of the Brooklyn Surgical Society deny any influence of trauma, 84 per cent accept it; of the latter, 33 per cent grant it a primary rôle, and 51 per cent acknowledge only a secondary rôle, aggravating a preexisting lesion. Denials of any traumatic influence by the New York Surgical Society are 31 per cent; acceptances 69 per cent, of which 29 per cent acknowledge trauma may be a primary factor and 40 per cent rate it as secondary. No relationship is voted by 24 per cent of the Chicago Surgical Society. Of 76 per cent who concede trauma to be influential, 9 per cent accept it on a primary and 67 per cent on a secondary basis. A survey at large showed 20 per cent opposing trauma as a factor. Of the 80 per cent accepting trauma, 26 per cent accepted a primary rôle and 54 per cent accepted trauma as playing a secondary aggravating rôle. In the final analysis of 243 opinions, 20 per cent deny any relationship, 24 per cent grant a primary influence and 56 per cent a secondary influence (Table IV).

CONCLUSIONS

(1) Appendicitis is a disease and not an accident. It cannot be produced by trauma alone. The primary cause of the disease is bacterial infection,

occurring in a vestigial organ possessing low vital resistance, susceptible to destructive changes on slight provocation. This provocation is furnished by slight abrasions of its mucous membrane from the presence of hardened fecal

TABLE IV

SURVEY OF OPINIONS FROM VARIOUS SOURCES

Opinions	No.	Deny Relationship	Accept Primary Relationship	Accept Secondary Relationship
From the literature	42	9%	38%	53%
Brooklyn Surgical Society	30	16%	33%	51%
New York Surgical Society	60	31%	29%	40%
Chicago Surgical Society	34	24%	9%	67%
Miscellaneous	62	20%	26%	54%
Foreign	10	11%	11%	78%
Canadian	5	0	40%	60%
Totals	243	20%	24%	56%

matter and especially by circulatory disturbances, the result of a shortened mesentery or angulation of the organ.

(2) One must take cognizance of two possibilities: namely, the effects of trauma upon: (1) The normal appendix and, (2) the pathologic appendix. There is substantial evidence to support the belief that both direct and indirect trauma may affect the appendix, but these cases are very rare in comparison with the large number of cases in which trauma has no part.

(3) The question of the correct evaluation of trauma rests largely upon: (1) Whether the patient has had previous attacks of appendicitis; (2) character of the force; (3) the time element; (4) the bridging of symptoms from accident to operation; (5) the pathologic findings at operation; (6) the final microscopic diagnosis.

(4) To admit that genuine primary traumatic appendicitis exists, the following rigid requirements must be met: (1) There must be no history of previous attacks. (2) The causative traumatism must be capable of reaching and affecting the appendix. The injuring body must be large, the force direct, blunt, violent and of limited duration. (3) The effects of the trauma must be immediately experienced, merge into those of acute appendicitis, must be properly reported, be disabling, require medical attention and operation at once. (4) True traumatic lesions of the appendix must be operatively demonstrated, namely, frank contusion, hematoma or effusion in the wall or mesentery, genuine rupture, laceration or puncture. (5) There must be a superimposed acute inflammation of the appendix, the result of the traumatic lesion diagnosed microscopically and no evidence of chronic pathology. Immediate operation may reveal only the true traumatic lesion and no appendicitis on microscopic examination. It is stressed that such lesions should not be called traumatic appendicitis until the inflammatory reaction has developed and been proven microscopically. Without these genuine lesions, coupled

with the necessary inflammatory reaction, the case of primary traumatic appendicitis has not been proven and its occurrence is a coincidence.

(5) To admit the contributory or aggravating influence of trauma, the following postulates are essential: It is stressed that the influence is here entirely secondary and that we are dealing with the traumatic effects upon old, preexisting pathology. The condition should not be called traumatic appendicitis. Appendicitis, aggravated by trauma, is best designated traumatic appendicopathy. The necessary requirements are: (1) There should be elicited a definite history of previous attacks. (2) The history of trauma must here also show a definite sequence and relationship to, and be correlated with, the operative findings. (3) The onset of symptoms characteristic of an exacerbation must develop at once and force the patient to stop work. (4) The occurrence must be properly reported. (5) The operative findings should show, conclusively, either genuine traumatic pathology with an added acute appendicitis or unquestioned pathology antedating the injury, with superimposed acute appendicitis. (6) The microscopic report of the sectioned organ should indicate acute appendicitis.

(6) There are no proofs that chronic appendicitis can be attributed to trauma.

(7) If operation is refused, or if delayed and late operation reveals only chronic microscopic pathology, the case should not be accepted as one of traumatic appendicopathy.

(8) If the attack following the accident sudsides and later recurs, the injury should not be held responsible for the second exacerbation.

SURGICAL CONSIDERATION OF SOLITARY POLYPS OF THE COLON

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THE records of cases in which surgical excision of solitary polyps of the colon was performed in the past 30 years have been reviewed. Only cases in which single polyps have been treated by transcolonic excision or exteriorization of the colon have been included in this report. Because of this arbitrary selection of cases, no conclusions of a general nature concerning the condition are to be drawn, but the problem presented by the patient and the surgical measures employed will be considered.

Much thorough investigation has been carried out on the subject of polyps of the large bowel. Wechselmann,[6] in 1910, and Dukes,[2] in 1926, demonstrated the origin and early stages of these polyps. Schmieden and Westhues,[5] in 1927, traced the transition of the very small adenomatous polyps from a typical benign glandular epithelium through a stage of glandular distortion, hyperchromatic nuclei, and cell-crowding, into a definite adenocarcinoma. They classified the polyps in three groups: Group 1 includes polyps covered with normal mucous membrane. Group 2 includes polyps invested with a mucous membrane; the cells of these polyps are hypertrophied, elongated, and compressed; the nuclei are stained deeply and there is a diminished production of mucus. In such growths a connective tissue framework is apparent. Group 3 includes polyps which have a most actively proliferating epithelium; the cells are arranged in piles and in them rapidity of growth has outstripped the connective tissue framework. Such polyps rarely attain any large size.

Fitzgibbon and Rankin[3] studied the fate of polyps of the large intestine. They used this classification and were of the opinion that the polyps of Group 1 will continue to be benign, that those of Group 2 will pursue an irregular, although ultimately malignant, course, and that the polyps of Group 3 always become malignant. In their review of 24 cases of carcinoma of the colon, they found definite evidence to show that the carcinoma originated in a preexisting polyp in 19 of the cases.

Saint[4] has studied polyps of the intestine and pointed out that the malignant change in a polyp almost always begins at the tip of the polyp and finally progresses to the stalk. He believed that while many polyps become

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malignant, most carcinomata of the large intestine develop without evidence of a preexisting adenoma.

It is impossible to state accurately what percentage of polyps become carcinomatous but the close relationship of polyps of the colon to carcinoma of the colon is part of the every day experience of one performing surgery on this part of the intestine, as one sees benign and malignant polyps often in the same excised specimen of the colon that contains a carcinoma. Schmieden and Westhues thought that 60 per cent of carcinomata of the colon originated in a polyp or polyps.

Brust[1] made a most thorough study of 143 cases of solitary polyps of the rectum and sigmoid colon which were low enough to be discovered with the sigmoidoscope, and found that there were no symptoms which could be called typical; in fact, only 20 per cent of the patients had symptoms which could be definitely ascribed to the polyp. No more than 65 per cent of the patients had rectal bleeding. Due to the fact that some of the patients with solitary polyps refused any treatment, he was able to study both the treated and untreated cases for a period of five years. Of those who were treated by fulguration of the polyps, none had developed carcinoma within five years. Of the patients who refused treatment, 7.3 per cent had developed carcinoma within five years.

Symptoms.—Twenty patients were operated upon for a solitary polyp of the colon. These were situated in the lower part of the descending colon or sigmoid colon in all instances except two, in which the polyps were in the transverse colon. Fourteen patients had bleeding from the rectum, which was of an intermittent type, persisting for two or three days and then being absent for a week or two. It is interesting that the bleeding was frequently described as coming after the stool, often amounting to an ounce or two of bright or dark-red blood. Abdominal pain was of infrequent occurrence, although in two cases, in which there were polyps of the sigmoid colon which were the size of an egg, there were attacks of severe pain which suggested intussusception, which was later confirmed at operation. Moderate constipation was the usual complaint of all the patients with the exception of four who suffered from loose stools and a mucous discharge. The age incidence was over 40 in all except five cases. One, a female, age ten, had had rectal bleeding for five years as a result of a polyp in the sigmoid colon. The polyps were identified by the air insufflation technic for roentgenography of the colon which is used by Weber at the Mayo Clinic.

Surgical Measures.—The patients are sent to the hospital three days prior to operation, for preoperative preparation. This consists of a residue-free diet, colonic irrigation twice a day, oral administration of sodium phosphate, and intraperitoneal vaccination. At operation, the colon is exposed and palpated between the fingers at the exact site of the polyp, as determined by the roentgenologist. Recognition of the polyp by this means may be somewhat difficult, especially if the polyp is small and the patient obese, as large epiploic tags may give the same sensation to the fingers as does a polyp.

Transillumination with the Cameron light may be used in conjunction with palpation in difficult cases. Once the polyp is definitely located, a rubber-covered clamp which has a semicircular, curved blade is placed over the involved segment of the colon to prevent the polyp from slipping away.

The colon is then carefully packed off from the remainder of the abdominal cavity, and a small incision, about 2 cm. long, is made along a longitudinal band of the colon. Precautions are taken to prevent any soiling. The polyp is grasped with an Allis forceps and delivered from the colon. The stalk of the polyp is crushed with forceps, the base ligated, and the polyp removed. The opening in the colon is then closed with two rows of chromic catgut sutures and epiploic tags are tied over the suture line.

Postoperatively, oral administration of fluids is withheld for three days and then a residue-free diet is given, which is gradually built up to a normal diet. A spool is kept in the rectum continuously for the first three or four days to facilitate the discharge of flatus.

COMMENT.—The importance of removing these polyps as soon as they are discovered is evident from the fact that five of the 20 polyps removed in this series of cases showed definite areas of adenocarcinoma, Grade I, on a basis of four. There were no deaths or postoperative complications in the entire series of 20 cases. Certainly it would have been much more dangerous to allow the polyps to remain than to have operated upon these cases.

REFERENCES

[1] Brust, J. C. M.: Solitary Adenomas of the Rectum and Lower Portion of the Sigmoid. Proc. Staff Meet. Mayo Clinic, **9**, 625–631, October 17, 1934.

[2] Dukes, Cuthbert: Simple Tumours of the Large Intestine and Their Relation to Cancer. Brit. Jour. Surg., **13**, 720–733, April, 1926.

[3] Fitzgibbon, Grattan, and Rankin, F. W.: Polyps of the Large Intestine. Surg., Gynec. and Obst., **52**, 1136–1150, June, 1931.

[4] Saint, J. H.: Polypi of the Intestine; with Special Reference to the Adenomata. Brit. Jour. Surg., **15**, 99–119, July, 1927.

[5] Schmieden, V., and Westhues, H.: Zur Klinik und Pathologie der Dickdarmpolypen und deren klinischen und pathologisch-anatomischen Beziehungen zum Dickdarmkarzinom. Deutsch. Ztschr. f. Chir., **202**, 1–124, 1927.

[6] Wechselmann, Ludwig: Polyp und Carcinom im Magen-Darmkanal. Beitr. z. klin. Chir., **70**, 855–904, 1910.

RESULTS OF CONSERVATIVE TREATMENT OF ACUTE CHOLECYSTITIS *

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THIS paper is an analytical study of 300 consecutive cases of clinically acute cholecystitis treated in the Roosevelt Hospital, New York City, since 1917. All of these patients were acutely ill, with pain, fever, leukocytosis and signs of acute inflammation in the upper right quadrant of the abdomen, on admission to the hospital. Many of our most eminent surgeons, during recent years, have advocated prompt surgical interference in cases of acute cholecystitis. The reason usually given is that the dangers of complications, such as gangrene, perforation and peritonitis, are greater than the dangers of operative interference in the acute stage of the disease. On January 24, 1934, Dr. Henry Graham[4] read a paper before this Society on this subject in which he stated that "the time has come when one must justify any delay in removing an acutely inflamed gallbladder." Brief discussions followed, in which there was no dissenting voice. A series of papers which were read and discussed on this subject at the meeting of the American Surgical Association in Washington, May 1933, and many articles in recent medical literature, all show a definite trend to earlier operation in acute cholecystitis. It seems logical that, because it took decades to teach the medical profession that an acute appendix should be removed immediately, the same slow process of education is being required to disseminate the gospel that the acute gallbladder requires the same treatment. Methods of treatment change with time. There is frequently the same tendency to cycles which is so characteristic of all human activities and customs. Any method of therapy, aggressively advocated by recognized leaders of surgical thought, may have wide acceptance by others without adequate critical study.

It has never been the policy at Roosevelt Hospital to operate immediately upon patients suffering from acute cholecystitis. The late Drs. Charles N. Dowd and Charles H. Peck, like the present Surgical Director, Dr. James I. Russell, were of the opinion that, while each case must be judged individually on its own merits, in general it was safer to give these patients time for the temperature, leukocytosis and acute symptoms to subside before surgical intervention. The patients were kept under close observation, the surgeon being ready to operate if signs of spreading peritonitis developed, or, if there was no improvement within four or five days. A cholecystostomy was considered a safer procedure than cholecystectomy in the presence of very acute inflammation. Although these are the general principles, many individual cases were

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handled differently according to that indefinable something called surgical judgment. This paper is a study of the results of this method of handling acute inflammations of the gallbladder over a 20 year period.

Many articles on acute cholecystitis are difficult to compare as they do not define what is meant by an "acute gallbladder." It is extremely important to indicate whether the diagnosis is based upon the pathologic findings or upon the clinical picture. Most classifications are based upon the pathologic picture. The argument of the proponents of immediate cholecystectomy, that it is impossible to judge the amount of pathologic change in the gallbladder by the clinical facts, is certainly true. This is immediately obvious to anyone studying acute cholecystitis. Almost every case which has been clinically acutely ill has abundant evidence of acute inflammation in the gallbladder, some even of perforation and gangrene, long after the clinical manifestations have subsided. It is an equally true and, an equally important observation, that the patient may not be as seriously ill as the lesion in his gallbladder would indicate. This fact has not been sufficiently emphasized. Many cases with very acute, severe pathologic changes in the gallbladder, even gangrene, rupture and local abscess, may be clinically chronic and run a very smooth postoperative course after cholecystectomy.

The borderline between acute and chronic cases is never sharp. Each case, herein considered, gave a history on admission of severe pain in the gallbladder region, had a rectal temperature of 101° F. or over, a leukocytosis of 12,000 or over, and definite muscle spasm and local tenderness. If all but one of these signs and symptoms were not present, the case has not been included. The charts of 1,474 patients admitted to Roosevelt Hospital with gallbladder disease during the 20 year period have been personally studied. This selection of cases has been made because it was felt it would include those cases which the advocates of immediate surgery would select for emergency operation on account of the acuteness of the clinical picture, thus making the study of value for comparison. It was impossible to find these cases except by studying the charts of all the gallbladder patients, as only about half of the cases, diagnosed acute by the pathologist, are clinically acute on admission to the hospital. This is especially true of the distended, edematous, often palpable gallbladder without other signs of acute infection. Most acute attacks are superimposed upon a chronic process, and the case may be filed as chronic cholecystitis without mention of the recent acute exacerbation. About one in five cases of all gallbladder disease admitted is included in this study of the acute cases. Cases with gallstone colic, without fever or leukocytosis, are not included. There are several cases of acute cholecystitis with an old rupture and a localized abscess in the gallbladder region which are not included, as on admission they had no fever, no leukocytosis and no acute symptoms, except perhaps tenderness and some muscle spasm in the gallbladder region. There are many more cases with areas of gangrene in the gallbladder wall, sealed off by peritoneal adhesions and not perforated, which are not included for the same reason. These cases clinically are chronic cholecystitis

despite the advanced pathologic picture in the gallbladder, and usually run a very smooth postoperative course without evidence of peritonitis. They were not included as they did not present the clinical picture indicating any necessity for immediate surgery. There is no dispute about the proper treatment of such cases. They should be operated upon as soon as they can be properly studied and prepared. We judge the seriousness of the intra-abdominal inflammation by the severity of the pain, the amount of fever and leukocytosis, and the degree of local signs, such as muscle spasm and tenderness.

In discussing the complications of acute cholecystitis, great emphasis is placed on the danger of gangrene, perforation and peritonitis. It will be shown that death from this sequence of events is rare. Areas of gangrene, though relatively common, are less serious complications than is frequently supposed, if cholecystectomy is not attempted in the acute stage. In almost 90 per cent of these patients the clinical manifestations will subside. Then, even in the presence of gangrene of the gallbladder with localized perforation, the postoperative course of most of them is smooth, possibly because vaccination against the infection has taken place, or perhaps, as suggested by Andrews,[2, 3] because the primary condition is not the result of infection. The deaths following late operation are not caused by peritonitis, but by some postoperative complication such as pneumonia, shock, hemorrhage, injury to the common duct, embolism, uremia, *etc.* Deferred operation also allows a period for accurate observation, study and preliminary treatment, which contributes to the safety of surgery.

TABLE I

ANALYSIS OF CAUSES OF THE 30 DEATHS

Peritonitis	6
Shock or hyperpyrexia within 72 hrs. P. O.	10
Pneumonia	5
Uremia	2
Anesthesia	1
Embolism	1
Delirium tremens	1
Liver abscess and portal vein thrombosis	1
Wound disruption	1
Chronic sepsis in wound	1
Senility	1

There were 30 deaths in this series, a mortality rate of 10 per cent. Only six, one-fifth of these deaths, were due to peritonitis, a mortality of 2 per cent from this complication. One case died of uremia without operation, one from senility, and one from delirium tremens, causes which probably had no connection with surgery. The remaining 21 cases all died as a direct result of operative procedures. They are classified as follows: Ten died within 72 hours after operation, with high fever and a very rapid pulse; five with postoperative pneumonia; two from uremia; and one each as the result of embolism, chronic sepsis in the wound, anesthesia, wound disruption, portal vein thrombosis and multiple liver abscesses (Table I). The ten cases dying

promptly after operation with high fever and rapid pulse can undoubtedly be subdivided further. Some were postoperative shock, one or two were possibly hemorrhage, and others so-called "liver deaths," where the exact cause is uncertain. Possibly an overwhelming septic cholangeitis is the immediate cause of most of these fatalities. Only three of the ten were autopsied, and no anaërobic cultures of the bile were taken. No matter what was the exact sequence of events, death followed the operation so promptly in these ten patients that there is no question but that it was the direct result of the surgical procedure rather than of the natural course of the disease. Eight of these early deaths were in cases where operation was performed in the presence of fever and leukocytosis. Considering the direct relation of the gallbladder circulation to the portal vein, it is surprising that more cases of portal vein thrombophlebitis and liver abscesses did not occur, but there was only one death from this cause, as was proven by autopsy. To summarize, in our 30 deaths, the number caused by peritonitis is only about one-fifth of the number caused by an operative complication. This situation is a direct opposite to the statistics in appendicitis, where peritonitis is the most common cause of death. No intestinal perforation occurs, and an entirely different bacteriology is involved in these cases. The two diseases are not comparable for this reason alone.

Many articles simply cite the percentage of cases complicated by gangrene and perforation of the gallbladder without further comment. To evaluate the clinical significance of perforation and gangrene of the gallbladder, it must be divided into three groups: (1) Free perforation, without adhesions, setting up a more or less diffuse peritonitis; (2) perforation into a nearby viscus, usually the duodenum; (3) gangrene and perforation walled-off by surrounding structures, causing a local peritonitis and abscess. Cases in the first group, free perforation setting up a diffuse peritonitis, are not easily diagnosed and are fortunately rare. There were seven in this series, all of whom died. Strangely enough, only two of these cases were diagnosed as diseases of the gallbladder upon admission. A review of these seven cases is instructive, as only one of them was a typical, acute cholecystitis, and four of them were operated upon as surgical emergencies under an incorrect diagnosis. One case came to autopsy before the correct diagnosis was made. Dr. Clarence A. McWilliams,[1] in 1912, published an exhaustive consideration on the subject of acute perforation of the biliary system into the free peritoneal cavity, in which he made similar observations. He was able to collect only 108 cases from the literature up to that date. The operated cases were diagnosed peritonitis from some other cause, such as perforated ulcer, appendicitis or intestinal obstruction. More recent articles also confirm these facts. It cannot be argued that these deaths from general peritonitis could have been prevented by more prompt surgery, except in one case where perforation occurred while under observation. The occasional death from this cause is usually given as an argument for early operation. I shall briefly review all seven cases to refute this argument.

ABBREVIATED REPORTS OF SEVEN CASES WHICH DIED AS THE RESULT OF GANGRENE, PERFORATION AND PERITONITIS

Case 1.—(B25213). A male, age 48, had been in the hospital four days waiting for subsidence of typical, acute cholecystitis symptoms. He had been sick only two days before admission and had had several previous, typical, less severe attacks. Temperature, 101° F.: leukocytes, 11,000; 86 per cent polymorphonuclears. He was very tender over the gallbladder, but there was no palpable mass. He was thought to be doing very well, when suddenly he had an attack of violent abdominal pain, the whole abdomen became board-like, his temperature rose rapidly to 104° F, his pulse to 120. He was operated upon immediately, under ether anesthesia, and an acute gallbladder with a small area of gangrene and rupture into the free peritoneal cavity was found. A simple cholecystostomy was performed, and large quantities of bile and numerous stones were removed from the abdominal cavity. He died 36 hours later with a temperature of 107.4° F.

This patient would probably have been saved by earlier operation, but is unique in the entire series.

The diagnosis was correctly made in one other case because of the presence of a little jaundice with the signs of general peritonitis.

Case 2.—(B207199). A male, age 51, had been sick about five days, with abdominal pain, vomiting, fever and prostration. He had had no previous attacks, but some indigestion. He was almost moribund on admission, with a rapid pulse, abdominal distention, a mild jaundice, temperature 100° F., leukocyte count 14,000, 90 per cent polymorphonuclears. He was operated upon immediately under local anesthesia. A gangrenous gallbladder and a diffuse peritonitis were found. A simple drainage was performed, but he died four hours later.

In the remaining patients the condition was not recognized.

Case 3.—(A343480). A female, age 30, very obese, had been acutely ill for two days with abdominal pain, vomiting, temperature 101° F., leukocytes 20,700. She was operated upon immediately, under ether anesthesia, as acute appendicitis with peritonitis. Gangrene of the entire gallbladder was found, the operator describing it as similar to wet blotting paper, with a diffuse peritonitis. A simple exploration and drainage was performed, and during the closure of the wound the patient suddenly stopped breathing. Death was ascribed to the anesthesia.

Case 4.—(B26510). A female, age 30, very obese, was admitted and operated upon, under ether anesthesia, at night as a case of acute appendicitis, probably ruptured. She had been sick for three days with abdominal pain, temperature 102° F., leukocytes 19,600, 90 per cent polymorphonuclears. Strangely enough, she did not have a very severe cholecystitis, but there was a small area of gangrene and perforation near the ampulla of the gallbladder with a diffuse bile peritonitis. A cholecystectomy was performed, but she died four hours after operation.

Case 5.—(A29802). A female, age 52, was admitted to the hospital, after being acutely ill for two days, and was operated upon immediately, with the diagnosis of acute intestinal obstruction of unknown origin. Vomiting, abdominal pain, distention and acute cramp-like pains were her chief complaints. Temperature 103° F., leukocytes 17,250. A gangrenous gallbladder with diffuse bile peritonitis was found. A simple drainage and cholecystostomy was performed. She did very well at first in contrast to the other six cases, but developed a secondary abscess which necessitated a second operation 36 days later, six days following which she died from pneumonia, 42 days after the original operation. Ether was used for the first operation and local infiltration with novocaine for the second.

Case 6.—(A33414). A male, age 48, was admitted to the hospital after having been acutely ill for three days. Temperature 103° F., leukocytes 15,000, 96 per cent polymorphonuclears. He was watched four days undiagnosed. An incision was finally made in his right flank for a possible perinephritic abscess, using ether anesthesia. An escape of huge quantities of bile-stained pus gave a clue to the correct diagnosis. A right rectus incision was then made, and a complete gangrenous gallbladder and diffuse peritonitis were found. The patient died with a high temperature in 48 hours.

Case 7.—(A370547). A female, age 58, colored had been sick almost a month before admission, with chills, fever and abdominal distention, but very little pain. She had been in the hospital, undiagnosed, for seven days. Extensive laboratory studies, including roentgenologic examination, Widal blood cultures, *etc.*, had been made in an attempt to explain her high septic temperature and leukocytosis of 13,600, 92 per cent polymorphonuclears, without any definite conclusions being arrived at. She was finally explored with the diagnosis of a probable obscure peritonitis. Pus, fibrin, and adhesions were found throughout the abdomen, but the patient was considered too ill to explore further. She died 24 hours later. At autopsy the cause of the peritonitis was found to be a completely gangrenous gallbladder.

Rupture of the gallbladder with general peritonitis is a rare complication of disease of this viscus, having occurred but seven times in this series. Only two of the seven cases were diagnosed correctly (Table II). Over half were operated upon immediately, with a preoperative diagnosis of some other surgical emergency. All these patients died, but in only one could the fatality be attributed to the conservative treatment of a recognized cholecystitis.

TABLE II

SEVEN CASES OF GENERAL PERITONITIS

Preoperative Diagnosis

Rupture of gallbladder with peritonitis	2
Ruptured appendix with peritonitis	2
Intestinal obstruction	1
Peritonitis—origin unknown	1
Perinephritic abscess	1

The second group of cases, in which the gallbladder ruptures into a nearby viscus, is also rarely diagnosed as acute cholecystitis. It did not occur in this series. In one case, the operator believed it was about to occur. This patient was admitted to the hospital after being acutely ill for three days and had subsided clinically, when she was operated upon ten days later. A cholecystectomy had been planned. There was a small abscess between the duodenum and the gallbladder, containing a large gallstone, walled-off with adhesions so dense that the operator was afraid to perform a complete cholecystectomy on account of danger of damage to the duodenum. A simple cholecystostomy and removal of the impacted stone was effected. The patient made a very smooth recovery and remained well for the two years she was followed in the follow-up clinic. In reviewing three cases of small intestinal obstruction from large gallstones which had eroded through into the lumen of the small intestine, none of them had been clinically recognized as instances of acute cholecystitis before admission. One gave no history suggesting gallbladder disease, and the other two gave a history of chronic cholecystitis which had,

however, not been recognized. Perforation of the gallbladder into a nearby viscus is not a complication of acute cholecystitis as it was here observed.

The third group, gangrene and perforation sealed off by surrounding structures, with a local peritonitis, presents an entirely different story. Gangrene of the gallbladder was mentioned in 30 cases, gangrene and local abscess in 31 more, a total of 61 cases, or 20 per cent of the entire series of 300 cases. This rate of incidence compares closely with the published experience of others. Gangrene of the entire gallbladder was rare, but necrosis of the entire mucosa, with smaller areas of gangrene extending through all layers of the gallbladder, was common. These patients tend to show subsidence of clinical symptoms on waiting. Several such cases had no acute symptoms on admission to the hospital, and are, therefore, not included in this study. Eight of these 61 cases with local gangrene or rupture died, but five, or over half of these fatalities were operated upon immediately upon admission, in the acute stage of the disease, and four of these five fell into the group dying promptly with a high temperature. Surgery, not the natural course of the disease, was the cause of these deaths. Gangrene and perforation with localized abscess was mentioned in 20 cases which had subsided clinically, and only one of this group died, the cause being a postoperative pneumonia. This type of perforation of the gallbladder is relatively common as advocates of immediate surgery claim, but if left alone, it does not spread into a diffuse peritonitis and the patient has tremendous recuperative powers against it. The dangers of surgery in the acute stage are greater, in our experience, than those of the natural course of the disease. This fact is also brought out by a study of the patients operated upon immediately, in the presence of acute symptoms, which are reviewed in Table III. Fifty-nine of the entire 300 cases or about 20 per cent, were operated upon within 12 hours of admission, 32, or over one-half of them, incorrectly diagnosed. Fifteen or 25 per cent of this group died, which accounts for half of the 30 deaths in the entire series.

TABLE III

CASES OPERATED UPON AT ONCE AS AN ACUTE EMERGENCY

Total number (20% of entire series)	59	
Incorrectly diagnosed	32	54%
Deaths	15	25%
Diagnosed acute appendicitis	19	32%
Diagnosed perforated ulcer	7	12%
Diagnosed peritonitis of unknown origin	3	5%
Diagnosed intestinal obstruction	1	2%
Diagnosed "acute abdomen"	2	4%

The common mistakes in diagnosis were, acute appendicitis, 19, perforated ulcer, 7, peritonitis of unknown origin, 3, intestinal obstruction, 1. In two cases the operator simply diagnosed an "acute abdomen" without further comment (Table III). Eight fatal cases in this group had been sick less than two days at the time of operation. All of the ten prompt postoperative deaths, with high temperature and rapid pulse, occurred in these 59 cases

operated upon in the presence of temperature and leukocytosis. It seems to me that these results unquestionably controvert the statement that cholecystectomy can be performed on these patients with relative safety in the acute stage of the disease.

The other 241 cases were kept under observation and allowed to subside for an average period of eight days, the longest 23 days. Two hundred eight of these, or 87 per cent, either entirely subsided or greatly improved. Many of these cases had temperatures of over 103° F., and leukocytes of over 20,000 on admission. Thirty-three, or 13 per cent, did not subside, or it was feared they were getting worse, so that operation was performed in the presence of acute symptoms. The average time waited on these feared unfavorable cases was five days, the longest 23. In studying the analysis of this group and the operative findings, I believe the surgeon was usually impatient

TABLE IV

CASES KEPT UNDER OBSERVATION TO ALLOW OF SUBSIDENCE

Average period 8 days—Longest 23 days

Total number	241	
Deaths	12	5%
Subsided or greatly improved	208	87%
Not subsiding or getting worse	33	13%
Average days waited 5, longest 23.		
Deaths from peritonitis	3	.2%
Deaths in 33 cases not subsiding	7	20%
Deaths in 208 cases which subsided	5	2.5%

or overanxious. There were seven deaths in this group of 33 cases, again showing the high mortality if operation is undertaken in the presence of acute symptoms. There were 12 deaths in the whole 241 cases treated conservatively, including the 33 unfavorable cases, a 5 per cent mortality. There were only five deaths in the 208 clinically subsided cases, a mortality of 2.5 per cent in this most favorable group (Table IV). The contrast to the 25 per cent mortality in cases operated upon in the acute stage is striking.

The operations performed were cholecystectomy, 202 cases, with 14 deaths,

TABLE V

OPERATIONS PERFORMED

Cholecystostomy	70
Deaths—13 (18.5%)	
Cholecystectomy	202
Deaths—14 (7%)	
Exploration only	2
Deaths— 2 (100%)	
No operation	26
Deaths— 1 (4%)	

a mortality of 7 per cent; cholecystostomy, 70 cases, with 13 deaths, or 18.5 per cent; simple exploration, two cases, with two deaths, or 100 per cent, and no operation on 26, with one death, or 4 per cent (Table V). Some of the

26 cases not operated upon refused operation because the symptoms had subsided. A few others were first attacks and operation was not strongly urged, and a few were considered too poor operative risks. The death in this group was due to uremia. No patient has been included in this group unless the diagnosis seemed unquestionable. The 18.5 per cent mortality following cholecystostomy as compared with the 7 per cent following cholecystectomy is misleading. Cholecystostomy, in general, was performed only upon cases when cholecystectomy, the operation of choice, was considered too great a hazard. Many of them were performed under local anesthesia, on very ill or elderly patients. Most of the patients with ruptured gangrenous gallbladders, operated upon in the presence of acute symptoms, had a simple cholecystostomy. The fact that over 80 per cent of these acutely ill patients recovered seems to me to be a tribute to the value of this operation.

In this study, several interesting facts about acute cholecystitis were brought out. One hundred nine cases, or over one-third, were men, a much larger proportion of males than occurs in chronic cholecystitis. This fact has been mentioned before, but no explanation is offered. The vast majority are in the third, fourth and fifth decades, but the ages range from 16 to 88 years. The average time ill before admission was four days, the longest 30 days. The 30 fatal cases had also been sick on the average of four days, the longest 30, but were only observed an average of two days before operation, the longest ten days (Table VI). As the deaths were mostly from

TABLE VI

DURATION OF ILLNESS—PERIOD OF OBSERVATION

Average time acutely ill before admission.....	4	days
(300 cases) Longest	30	days
Average time observed in hospital before operation.	8	days
(exclusive of cases operated upon immediately—total 241) Longest	23	days
Average time 30 fatal cases. Ill before admission...	4	days
Longest	30	days
Average time 30 fatal cases observed before operation	2⅓	days
Longest	10	days

operative complications, one wonders what the mortality would have been if they had been observed longer. A surprising number of patients attribute the onset of the attack to some dietary indiscretion. Two hundred twenty-seven patients, or about three-quarters of the cases, had had either previous attacks or a history of gas and indigestion, strongly suggesting gallbladder disease. Two hundred sixty-eight, or 98 per cent of the 274 cases operated upon, had stones. The operator did not always mention the exact location of the stones, but when he did, it was always noted that one was impacted in the cystic duct or in the ampulla of the gallbladder. This confirms the belief that obstruction of the cystic duct is either the cause or an essential factor in acute cholecystitis. In several of the cases without stones, the operator noted occlusion of the cystic duct. If occlusion of the cystic duct by

a stone is the common cause of acute cholecystitis, it is easy to see why 75 per cent of the cases have a history of previous gallbladder trouble.

In 124 patients, or 41 per cent, the doctor making the physical examination felt a definite abdominal mass in the gallbladder region, usually stating that the gallbladder was palpable, and in 44 more, there was a probable mass. Thus, in over one-half the cases, if the gallbladder could not be actually felt, there was a strong suspicion of it. In the remaining 132 cases, or 44 per cent, no mass could be felt, or there was too much muscle spasm to detect it (Table VII). In many of these patients, mention is made of the fact that the gallbladder could be felt while under anesthesia, before the abdomen was opened.

TABLE VII

300 CASES OF ACUTE CHOLECYSTITIS

Number with previous history of gallbladder disease	227	76%
Number of 274 operated cases with stones	268	98%
Number with definite palpable mass	124	41%
Number with probable palpable mass	44	15%
Number with no palpable mass	132	44%
Number with local physical signs over the gallbladder	297	99%

In attempting to correlate the degree of pathology in the gallbladder with the clinical symptoms, I am inclined to believe the degree and persistence of pain are a better guide than the temperature or leukocytosis. Counts of over 30,000 with 90 per cent polymorphonuclears and temperature of over 103° F. were common among cases which subsided clinically. Every case was tender locally and showed some muscle spasm in the gallbladder region, except three of the unusual cases of general peritonitis already discussed. It was this absence of tenderness in these unusual cases which misled the surgeons in arriving at the correct diagnosis. In describing the acute gallbladder a very common statement in the operative report was that the gallbladder was the same color as the liver. Every case had some pain, most of them very severe pain. It was almost always the chief complaint. Many described vague pains for a few hours, then sudden, excruciating, severe, constant, abdominal pain referred through to the back. Many referred it to the epigastrium, rather than to the usual gallbladder region. The attack of acute pain usually had a very definite onset, the patient being able to state the exact time his trouble began. A surprising number relate that they had had similar attacks but none nearly so severe as the one which brought them to the hospital. Many are admitted through the emergency department almost immediately after the onset. Several cases incorrectly diagnosed as appendicitis had visceroptosis and hence a low-placed gallbladder. The average time spent in the hospital after operation was 18.5 days.

SUMMARY.—A statistical study of 300 consecutive cases of, clinically, acute cholecystitis covering a 20-year period is presented. There were 30 deaths, a mortality of 10 per cent. The cases were all treated at Roosevelt Hospital, where the general policy is to wait until the acute symptoms have

subsided. Of the 241 cases so treated, 12 died, a mortality of 5 per cent. There were 59 cases who were operated upon immediately, about half because of mistake in diagnosis, the other half because it was believed that the gallbladder had either ruptured or that rupture was imminent. Of these 59, 15, or 25 per cent, died. Half of all the deaths of the entire series occurred in these 59 cases. Twenty per cent of the entire series of 300 cases showed at least some gangrene of the gallbladder wall, and half of these were ruptured with resultant local peritonitis. Even these cases tend to subside, clinically, into an afebrile stage, at which time operation can be performed with much greater safety. There were only seven cases of general peritonitis and of these, four were so atypical that they were not recognized as originating from gallbladder disease. Only one case of typical acute cholecystitis developed general peritonitis while under observation.

CONCLUSIONS

Operation upon the acutely inflamed gallbladder in a very ill patient, in our experience, gives a much higher mortality percentage than conservative treatment.

The common cause of death is not peritonitis, or the natural course of the disease, but postoperative complications.

The low incidence of death from peritonitis is in direct contrast to the course of appendicitis and the two diseases are, therefore, not comparable.

REFERENCES

[1] McWilliams, Clarence A.: ANNALS OF SURGERY, **55**, 235–267, February, 1912.
[2] Andrews, Edmund, and Henry, L. D.: Arch. Int. Med., **56**, 1171–1188, December, 1935.
[3] Andrews, Edmund: Arch. Surg., **31**, 767–793, November, 1935.
[4] Graham, Henry F., and Waters, Henry: ANNALS OF SURGERY, **99**, 893, June, 1934.

DISCUSSION.—DR. CONDICT CUTLER, JR., (New York), said that Doctor Pennoyer's series represented the run-of-the-mill type of case as it comes into the hospital service. Perhaps the points of view of those who recommend immediate surgery and those who advocate delay are not so divergent as they might seem to be. Possibly the most conservative surgeon recommending delay in operation in instances of acute gallbladder would agree that, if the case could be seen early enough (not two or five days after onset of the attack but within a few hours as one sees the acute appendix), the patient might be more ideally treated by cholecystectomy. If that criterion were followed it would, of course, include not only cases which frequently go on to acute cholecystitis and gangrene but also would include cases of hydrops. If that were done, the mortality would be much lower than in either of the types of procedure cited.

Doctor Whipple's observation in regard to the lowered mortality where cases are operated upon within 48 hours lends some emphasis to that point of view.

Recent developments in the bacteriologic study of the gallbladder would seem to indicate that there is sufficient reason for removing the focus of infection, and yet cholecystectomy in the presence of a very active, acute, fulminating infection of the gallbladder presents certain technical difficulties. We are all familiar with cases in which we have performed a difficult chole-

cystectomy, only to have the patient die subsequently, and we wish we had not been so radical. The patient who comes to us with a cholecystitis of four, five or six days' duration is perhaps in the worst possible condition for immediate and radical surgery. We may regard the problem from the theoretical point of view. I have examined Doctor Pennoyer's series and noted the results obtained in some of the cholecystostomies. There were 70 in his series, with 13 deaths (18.5 per cent). There were 24 known satisfactory results—that is to say, cases that were followed for two or more years, without recurrence of either the gallbladder symptoms or the presence of a fistula. There were six cases which required reoperation, one for a persistent fistula and four who returned because of recurrence of the gallbladder attacks. Twenty-seven left the hospital healed but had no further record kept because they could not be followed.

Cholecystostomy is not necessarily an operation which will be followed by recurrence of the disease or by serious complications. I believe that in the more serious type of case, where the technical difficulties are great and inflammation profound, it may save the patient even though it does not cure his disease.

Dr. John Douglas (New York) thought Doctor Pennoyer had proved his point of view statistically, but Doctor Graham has proved the opposite point of view statistically. However, if anyone has read the statistics of Doctor Heuer, covering 1,000 cases from New York Hospital and more than 20,000 from the literature, the statistical proof is that operation should be performed early and not be deferred. Statistics, no matter what they are, can be utilized for either point of view because certain imponderable questions are involved which may be used to prove almost anything. We are all more or less swayed by personal experiences. Up to seven or eight years ago, I accepted the attitude of delay in gallbladder surgery, and then in a comparatively short time had two patients die as a result of delay—one who was sick for about a week before coming to the hospital, and who had perforated before admission; and the other, a patient apparently too sick to be operated upon, who had an accompanying lung and heart complication. Autopsy in the latter showed gangrene, perforation and peritonitis. Those two cases in my own experience influenced my opinion, perhaps wrongfully, more than the statistics.

In 1930, Miller and Mentzer presented papers advocating early operation; two years later two more papers by Zinninger and by Mentzer, with the same purpose, were written, and then, in 1933, three papers were presented before the American Surgical Association, all of which criticized delay, and which met with the general approval of the members.

As Doctor Pennoyer has said, the symptoms, laboratory and physical findings may be quite at variance with the pathology going on in the gallbladder. Very often, too, when those symptoms and signs have subsided there is still an inflammatory process progressing. How can anyone know that the process is not progressing, when the symptoms, and both laboratory and physical findings, do not show it? Several years ago, therefore, I changed my point of view and decided to operate upon early cases of acute cholecystitis. One advantage is that the dangers of perforation and abscess in acute gallbladder cases are considerably less than when you delay. Later the operation is more difficult because of dense adhesions between the colon, gallbladder and omentum. I do not believe that an acute cholecystitis should indicate an emergency operation as in an acute appendicitis. But with ade-

quate preparation and study of the patient, both the mortality and the morbidity may be improved with prompt operation rather than delay.

Dr. Allen O. Whipple (New York) thought Doctor Pennoyer's paper very interesting because it brought out a great many points for argument. Personally, up until five or six years ago, he had felt very strongly regarding the treatment of cases of acute cholecystitis conservatively. Then, after analyzing the acute cases, especially of his own, at the Presbyterian Hospital, he began to become a little uneasy about this position, and was not at all sure that many of the cases would not have done better if operated upon during the early period. In talking this over with Doctors Stone, Heuer, Morris K. Smith and others, he began to change his opinion, and, particularly during the last three years, has changed his policy. He had not performed a cholecystostomy in the last two years for acute cholecystitis, which meant that he had operated upon his cases at an early stage, before they had passed the edema phase.

One of the most interesting studies, in a number of years, is that of Edmund Andrews on acute cholecystitis, who points out a good many facts which Doctor Whipple said he had noted but had not correlated. One was that in many cases it is not possible to get positive cultures in, what appears to be, a very acute inflammation of the gallbladder. Another surprising fact is that many of these cases, where it is thought there is an empyema, have sterile cultures. In many cases there is a stone in the cystic duct or in the ampulla, apparently shutting off the blood flow from the gallbladder; many of these cases are not an acute bacterial cholecystitis but the result of edema and obstruction of the blood supply. If they are allowed to go on and quiet down, they will develop an acute bacterial infection; that is one reason why pericholecystitis and abscesses developing in the gallbladder are found and explains why they become more difficult to remove later.

There are some things in Doctor Pennoyer's paper which might be criticized. One is with regard to the ten cases characterized as so-called "shock." It is exceedingly unfortunate that cultures were not taken in those cases and that so few came to autopsy. The most rapid deaths following biliary tract disease, in Doctor Whipple's experience, were in three cases which he observed with *Cl. welchii* infection; they died just as does the patient from "liver shock." It pays to take cultures of all gallbladders. If a gallbladder is diseased enough to be taken out it is pathologic enough to be cultured. More than half of the 26 typhoid carriers that have been found at the Presbyterian Hospital have been discovered as a result of taking regular cultures from removed gallbladders. Many of the patients did not know that they had had typhoid.

The deaths following cholecystostomy in the series reported by Doctor Pennoyer were 18.5 per cent. Of course, it may be said that these patients were so sick that all one could do was a cholecystostomy. That is not questioned, but it does seem that many of these cases, if operated upon at an earlier stage, would not have had to have a cholecystostomy. Certainly, in Doctor Whipple's figures, the mortality in early acute inflammation of the gallbladder has been lowered as has also the number of cholecystostomies, which before carried a much higher mortality rate than cholecystectomy.

In Doctor Pennoyer's series eight deaths occurred in patients who were operated upon immediately, but the diagnosis was obscure; they were not typical acute cholecystitis cases. They had had the disease for at least 48 hours, the average was four days. They were atypical cases, and had really gone beyond the stage of acute cholecystitis. It does not seem that one should

necessarily blame the operation for the mortality in this particular group. One can argue both sides of this question, but one should be openminded and weigh the evidence in the various groups. However, a change of opinion has taken place, and the time has come when both sides should be studied.

Dr. Henry F. Graham (Brooklyn) said all surgeons desire to restore patients to health in the shortest possible time and with the least suffering and expense. Doctor Pennoyer's conclusions cannot be lightly brushed aside whether they are agreed with or not. The author, however, should have included in his statistics some of the cases which he has omitted; namely, those described thus: "There are many more cases with areas of gangrene in the gallbladder, well sealed off by peritoneal adhesions and not perforated—and several cases of acute cholecystitis with an old rupture and a localized abscess in the gallbladder region, which are not included, as on admission they had no fever, leukocytosis or acute symptoms except perhaps some pain, tenderness and local muscle spasm." In Doctor Graham's experience, such cases may require multiple operations, which tend to increase the mortality.

The danger of operation in acute cholecystitis cannot be demonstrated in a hospital that usually practices delay, for only the bad cases will receive early operation. Conversely, a hospital that believes in early operation cannot speak with authority about the dangers of delay.

Ninety-seven consecutive cases of acute cholecystitis, occurring on Doctor Graham's service at the Methodist Hospital during the past eight years and four months had been analyzed. Most of the diagnoses have been confirmed pathologically but a few were noted only in the surgeon's operative report.

In order to advocate early operation some time must be set. It might be said that early operation means within five days of the onset of symptoms. If that is accepted, Doctor Grahams' figures would show 75 cases with four deaths, a mortality of 5.6 per cent. Frederick Taylor reported 39 cases, with 5 per cent mortality, which had been operated upon within five days. Pratt, from Wayne Babcock's Clinic, reported 45 suppurative and gangrenous gallbladders. There was only one fatality in those operated upon within nine days, and none within 48 hours of the onset of the symptoms. In the total series, ten died—all but one were delayed from eight to 39 days. A cholecystectomy was performed upon all who recovered. Cholecystectomy, therefore, would appear to be a better procedure than cholecystostomy. Heuer's 3.9 per cent mortality is well known. One cannot ignore his clear demonstration that more than 20 per cent of the acute cholecystitis cases go on to gangrene or perforation. Morris Smith found the same to be true. In these acute gangrenous cases after five days the mortality is tremendous. Taylor showed 37.5 per cent mortality in 16 cases, and in Doctor Graham's series, of only five, there was 60 per cent mortality. Doctor Graham said he personally did not feel like watching these virulent infections. The only other alternative is a campaign to get them earlier.

Dr. Grant P. Pennoyer (closing): Deaths from general peritonitis do occur as in the cases mentioned by Doctor Douglas, but, in our experience, the mortality rate from this cause is less than 2 per cent of all acute cases, a death rate much lower than the operative mortality when cholecystectomy is performed in the presence of fever and leukocytosis. As regards Doctor Graham's case of a gangrenous gallbladder in a patient whose clinical symptoms had nearly all subsided, we have many parallel cases. There is no dispute about this group; they should be operated upon as soon as they have

been properly studied. If the fever and leukocytosis have subsided, cholecystectomy in this group has a very low mortality rate, in our experience, regardless of the advanced pathology in the gallbladder. Doctor Graham's tables, showing increased mortality according to the duration of symptoms, are interesting. I think the difference may be due to the fact that he did not wait long enough. If one is going to treat a case conservatively, it is important to wait until the fever and leukocytosis have disappeared. Our results show a high mortality in this small group, who were operated upon late with persistent acute symptoms.

One cannot deny the fact that in our series of 300 consecutive cases of acute cholecystitis, almost 25 per cent of 59 cases, who were operated upon immediately as emergency cases, in the presence of fever and leukocytosis, died, while there was only a 6 per cent mortality in the 241 cases who were kept under observation in order that they might subside. This mortality percentage includes seven deaths which occurred in 33 cases who were operated upon with persistent fever and leukocytosis, because the surgeon feared they were not showing sufficiently rapid improvement. The mortality rate was only 2.5 per cent in the 208 cases which were not operated upon until the clinical symptoms had subsided.

Doctor Whipple's criticism of the lack of autopsies, and especially bacteriologic study of the liver, in the cases dying promptly postoperative, with high temperature and rapid pulse, is well founded. We regret this very much, as such a study might help to settle this whole question. Certainly these deaths are a direct result of the operation and their total number is larger than the number of deaths resulting from rupture of the gallbladder and general peritonitis. Deaths will occur in any system of treating acute gallbladder disease. It is our experience that their number is increased, rather than decreased, by early operation.

SPONTANEOUS POSTOPERATIVE RUPTURE OF THE BILE DUCTS

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THE following case exemplifies a most serious complication resulting from the technical blunder of overlooking stones in the common or hepatic ducts.

Case Report.—A. D., a white female, married, aged 44, was admitted to the hospital January 25, 1937, complaining of pain in the stomach and vomiting. Her past history was essentially irrelevant. The present illness probably began before 1923, with pain under the right costal margin associated with nausea, vomiting and pruritus. By 1936, jaundice was added to the previous symptom-complex and the attacks occurred with increasing frequency. A provisional diagnosis of stone in the common duct was made.

Physical Examination.—There were no significant findings other than tenderness on pressure in the right upper quadrant which was increased by pressing the fingers under the costal margin on inspiration.

Laboratory Data.—The gallbladder could not be visualized roentgenologically; bile and albumin were present in the urine, the van den Bergh direct was slightly positive and the icteric index was eight. Other determinations were of no particular interest.

Operation.—February 11, 1937: The gallbladder was normal in size and appearance and contained a few stones. A large nest of them was noted at the junction of the common and cystic ducts. Numerous pigmented calculi, ranging in size from a few millimeters to 1.5 cm., were milked out of the ducts through an incision in the cystic and common ducts. The ducts were explored with sounds and a gallbladder scoop. Olive sounds were easily passed through the sphincter of Oddi into the duodenum and up into the hepatic duct without grating or resistance. The common and hepatic ducts did not admit a finger for intraductal digital exploration. The ducts were irrigated with saline solution through a soft rubber catheter but no further stones were found. The gallbladder was excised. The common duct and the 1 cm. long stump of the cystic duct were sutured, water-tight, around a soft rubber catheter.

Postoperative Course.—The first two weeks of convalescence were uncomplicated. The incision healed per primam and the catheter drain was taken out on the eighth day. Bile drainage from the stab wound fistula ceased on the seventeenth day. On the following day there was upper abdominal pain, persistent vomiting, and a temperature rise to 104° F. Two days later the attack subsided with the passage of a greenish stool. Ten days later, however, there was again biliary drainage from the fistula.

The fistula closed a second time on the thirty-eighth day; bile appeared in the stool one week later; two weeks after this second closure the fistula reopened. A fistulogram on the fifty-eighth day showed a complete common duct obstruction (Fig. 1) but the third and final closure of the fistula occurred on the sixtieth postoperative day. Bile was present in the stool. For one month after this the patient seemed perfectly well and was ready to be discharged.

Suddenly, on the ninety-sixth postoperative day, a biliary peritonitis occurred with severe upper abdominal and shoulder pain, vomiting, rigidity, a temperature of

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106° F. and an icteric index of 20. Six days later about two liters of foul smelling, greenish-brown bile were evacuated from the peritoneal cavity through a small upper right rectus incision under local anesthesia. The patient's condition precluded an exploration of the ducts. In spite of apparent improvement, the patient died four days later, May 27, 1937, 106 days after the primary operation.

Postmortem Examination.—A partial necropsy disclosed a moderate amount of cloudy, bile-stained fluid with a fecal odor in the peritoneal cavity, the largest collection

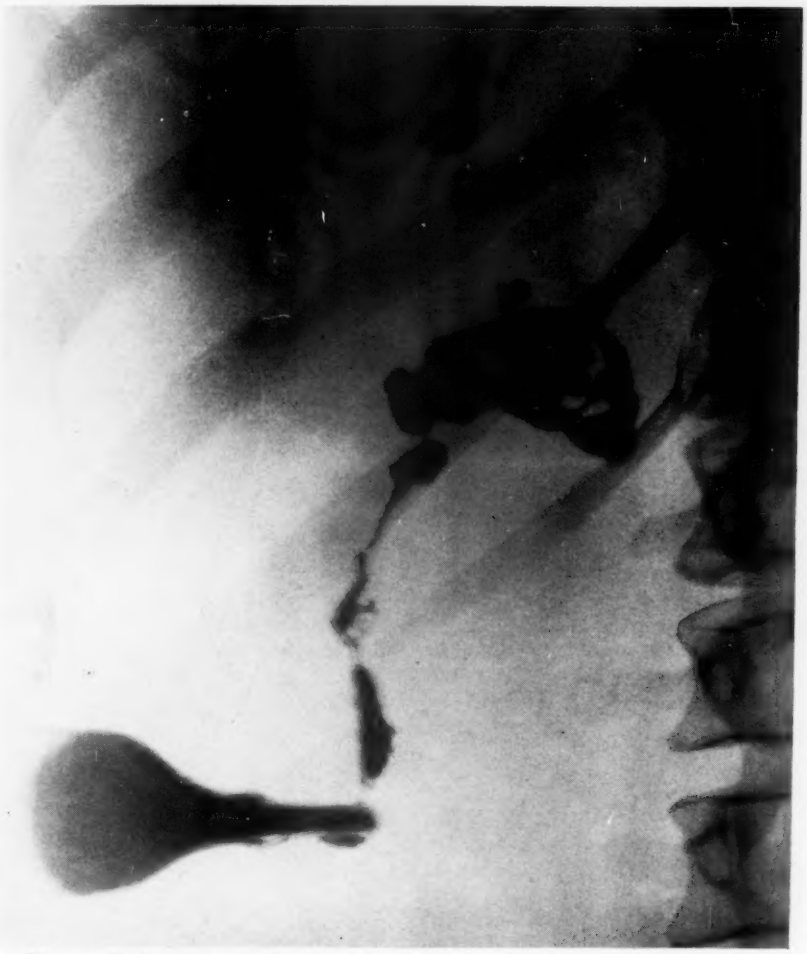

FIG. 1.—Cholangiogram. The "negative" shadows probably represent stones; if so, their position had changed prior to death. The "negative" shadows are very much more pronounced in the illustration than in the film itself. Unfortunately the diagnosis of obstruction due to stone was not made.

being in the pelvis; distended loops of intestine matted together by fibrinous adhesions; the duodenum densely adherent to the under surface of the liver. A transverse, roughly oval perforation 1 cm. in diameter with smooth rounded edges was present about 2 Mm. from the dome of the 4 cm. long cystic duct stump. At the junction of the hepatic, cystic and common ducts, one inside each, were three faceted, roughly hexagonal, black pigmented stones, each about 1.5 cm. in diameter (Fig. 2). That in the common duct was 3 cm. from the ampulla and lay in a shallow pouch. The common duct and cystic stump were definitely dilated, the hepatic only slightly.

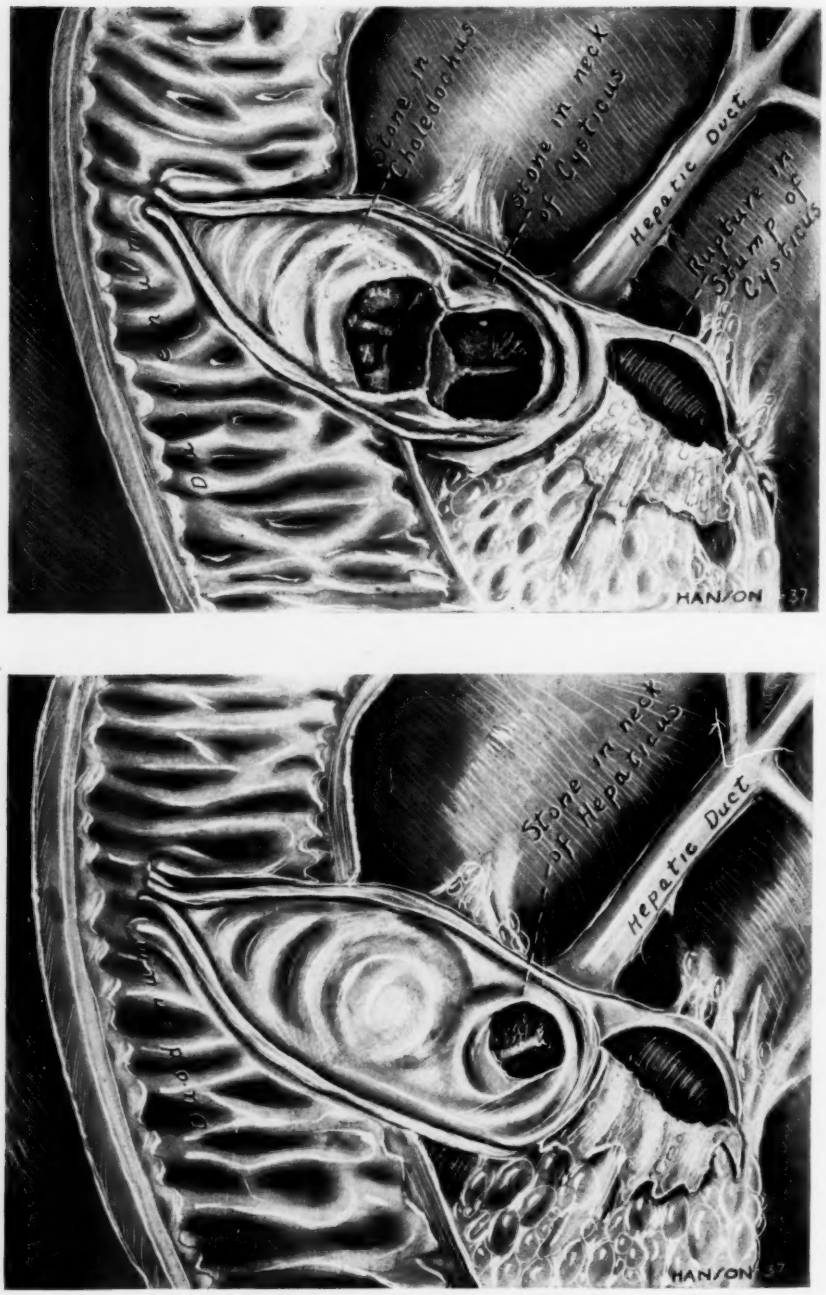

FIG. 2.—Drawings of the duodenum and common duct opened on their posterior aspects showing stones, rupture and dilatation. The lower drawing shows the stone in the hepatic duct after removal of those in the common and cystic ducts.

Microscopic examination of the rupture showed necrotic edges with complete loss of the lining mucosa. Throughout the cystic, both above and at the level of the rupture, and in the common duct the mucosa had been destroyed and a patchy but

TABLE I

NINE CASES OF RUPTURE OF THE BILE DUCT CONFIRMED BY OPERATION OR AUTOPSY

Case	Author	Age	Sex	Operations on Biliary Tract	Interval Between Last Biliary Op. and Rupture	Site and Type of Biliary Tract Drain	Point of Rupture	Location of Overlooked Stones	Result
1.	Dick[10]	56	F.	(1) Cholecystectomy; (2) choledochostomy 2 yrs. later	1 yr. (circa)	Supra-duodenal; type of tube?	Cystic duct	Papilla	Died
2.	Newburger	44	F.	Cholecystectomy and cysticocholedochostomy	3 mos.	Cystic duct; catheter	Cystic duct	Junction of cystic and hepato-choledochus	Died
3.	Popovici and Ghimpetzeanu[24]	23	F.	Cholecystectomy	12 days	None	Cystic duct	Retro-duodenal choledochus	Died
4.	Bernhard[3]	37	F.	Cholecystectomy and choledochostomy	3½ yrs.	Supra-duodenal; T-tube	Cystic duct	Papilla	Died
5.	Mirizzi[21]	?	F.	Cholecystectomy and choledochostomy	4 mos.	Supra-duodenal; T-tube	Point of drain in common duct	None	Died
6.	Bernhard[4]	56	F.	Cholecystectomy and choledochostomy	5 wks.	Supra-duodenal; type of tube?	Point of drain in common duct	None	Died
7.	Bernhard[4]	54	F.	Cholecystectomy and choledochostomy	4½ mos.	Supra-duodenal; type of tube?	Point of drain in common duct	In peritoneal cavity near rupture	Died
8.	Wolfson and Levine[30]	55	F.	(1) Cholecystectomy; (2) choledochostomy 25 yrs. later	55 days	Supra-duodenal; T-tube	Common duct	Felt in duct	Well*
9.	Wolfson and Levine[30]	26	F.	Cholecystectomy and choledochostomy	26 days	Supra-duodenal; catheter	Common duct	None	Died

* Common duct stones were removed a few months after recovery from the biliary peritonitis.

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extensive granulation tissue with round cell infiltration was found to extend through the submucosa of both ducts. The mucosa of the hepatic radicals was intact and their submucosa was not inflamed. The pancreas and liver showed no marked abnormality.

Twelve cases of rupture of the extrahepatic bile ducts following either simple cholecystectomy, choledochostomy or, in the majority of cases, the two combined, have been found in the literature. Of these, eight have had either operative or autopsy confirmation of the rupture (Table I).

Four were assumed to be due to rupture of the common or cystic ducts but were not confirmed. (1, 11, 26—Case 1, 30—Case 3.)

Perforations occurred in all decades from the third to the sixth inclusive, with the greatest number in the latter. All the patients were women. The interval between the last definitive operation on the biliary tract and the rupture varied from 12 days to 35 years. Cholecystectomy had been performed in all; in six combined with simultaneous choledochostomy, and in two it was followed after a period of years by choledochostomy. The choledochostomy was supraduodenal in seven with a T-tube in three of them, a catheter in one and an unspecified type of drainage in three others; a cystico-choledochostomy was performed in one with the incision extending on to both cystic stump and common duct; and in the one simple cholecystectomy no intraductal drainage was employed.

The rupture occurred in the cystic stump in four cases; once each in the dome, in the ventral wall at the point of incision just distal to the dome, 1.5 cm. from the ligature on the end of the cystic and at the junction of the cystic with the common duct. Twice the incision or ligature were implicated, twice not. In five cases the rupture took place in the common duct; three at the point of drainage, two probably at the point of drainage but not specified.

The number of overlooked stones varied from one to three and were found once at the papilla, once in the retroduodenal common duct, once at the junction of the common, cystic, and hepatic ducts, once in the free peritoneal cavity near the rupture and once intraductal but not specified. In two cases no stones were found.

Eight of the nine cases died; the one which recovered had stones successfully removed a few months after the occurrence of the biliary peritonitis.

Sources of Biliary Peritonitis.—Other causes of biliary peritonitis are much more common than spontaneous, postoperative perforation; for example, biliary peritonitis without macroscopic perforation of the gallbladder or bile ducts[7, 29] and gangrene and perforation in gallbladder diseases.[14, 17, 20] Some unusual sources are operative and accidental trauma[14] and rupture of an intrahepatic bile duct.[29]

Incidence of Overlooked Stones.—Best[5] summarizes the views of many surgeons[2, 9, 13, 19, 23, 28] in saying that "it is my very definite impression that many stones are left within the hepatic and common ducts although the ducts

may be thoroughly palpated, scooped, probed and irrigated." This belief is corroborated by some clinical and necropsy studies. Jung[16] found 16.4 per cent of stones left postoperatively in the ducts in his necropsy material. Bernhard,[2] reporting the results of 750 choledochostomies followed at the Giessen Clinic, found "at least 5 per cent of stones overlooked in the choledochus"; Bruening,[6] from the same clinic, had found 20 per cent of overlooked stones, and W. J. Mayo[19] reported that "in nearly one-third of the deaths which followed operation upon the common duct for stones in our series, postmortem revealed that all stones had not been removed."

Etiology of Rupture.—Four causes of bile duct rupture are currently discussed and are listed according to what seems to be their relative degree of probability.

(1) Increased intraductal pressure with bursting at the critical point of distention. This increased back-up pressure is in all likelihood due to mechanical blockade by stones, by a reflex spasm of the sphincter of Oddi, or by the two working in conjunction.

In three of the reported cases, certainly, and three more, probably, stones did act as obturators.

The locus of lowered cohesive strength caused by the choledochostomy incision or its scar, or the cystic duct stump ligature point was a factor determining the site of rupture in the majority of cases (Table I—Cases 2, 5, 6, 7, 8, and 9). But in the case of Popovici and Ghimpetzeanu[24] the rupture occurred 1.5 cm. from the line of closure, while in Bernhard's[3] case (Table I—Case 4) the cystic duct stump perforated at its entrance into the common duct; both the latter cases away from both incisions and stones.

(2) Infection, in the form of cholangeitis, undoubtedly, by destruction of the mucosa and elastic tissues, weakens the duct walls and lowers their resistance to possible increased intraductal pressure.

(3) Thrombosis, possibly of the cystic artery, might account for both of the above cases in which the perforation in the cystic duct stump occurred widely separated from any operative trauma.

(4) Activation of reflux pancreatic juice through a common opening of the pancreaticus and choledochus with tissue digestion. Unfortunately for this hypothesis fat necrosis was not noted in any of the nine cases. Popper's[25] findings of pancreatic ferments in 20 cases without gangrene or perforation of the gallbladder, and no pancreatic ferment in cases with acute or gangrenous cholecystitis and empyema or perforation of the gallbladder, also tends to weaken this assumption; so, too, does the anatomic relationship of the common and pancreatic ducts.[18]

COMMENT.—There is obviously a need to increase the degree of precision with which the biliary tract is explored during operation. The work of Mirizzi,[22, 31] Hicken, Best and Hunt,[15] and Robins and Hermanson,[27] on the development and modification of immediate cholangiography, if not conclusive, is, at least, a marked advance over the unreliable tactile examination.

SUMMARY

A case of postoperative perforation of the stump of the cystic duct is reported and eight cases of postoperative rupture of the extra hepatic biliary duct system are abstracted from the literature. The incidence, etiology and avoidance of this complication are considered.

BIBLIOGRAPHY

[1] Barthelemey, M.: Deux sequelles tardives de la cholecystectomie—(1) cholecystite calculeuse a six mois de date dans le moignon du cystique; (2) Peritonite biliare par perforation trois mois après guerison complete. Bull. et mem. Soc. nat. de Chir., **61**, 355, 1935.

[2] Bernhard, Fr.: Ueber die Erfahrungen bei 1000 Choledochotomien aus den Jahren 1895–1932 und ihre Spaetergebnisse auf Grund von Nachforschungen bzw. Nachuntersuchungen. Deutsch. Ztschr. f. Chir., **246**, 1, 1935.

[3] Bernhard, Fr.: Die Spontanruptur des Choledochus nach 3 Jahre zuvor Ausgefuehrter Choledochotomie. Zentralbl. Chir., **54**, 993, 1937.

[4] Bernhard, Fr.: Die spontane Ruptur des Choledochus nach vorausgegangener Choledochusdraenage. Zentralbl. Chir., **62**, 1813, 1935.

[5] Best, R. R.: Personal communication, 1937.

[6] Bruening, A.: Statistisches ueber 367 Choledochotomie. Deutsch. med. Wchnschr., **38**, 1543, 1912.

[7] Butkiewicz, T.: Die Gallige Bauchfellentzuendung ohne Perforation der Gallenwege. Arch. klin. Chir., **185**, 55, 1936.

[8] Colp, R.: Calculous Obstruction of the Common and Hepatic Bile Ducts. Annals of Surgery, **86**, 890, 1927.

[9] Demel, R.: Operative Behandlung der Steinerkrankung der Tiefen Gallenwege mit einem Bericht ueber die Technik und Dauererfolge. Klin. Wchnschr., **15**, 1649, 1936.

[10] Dick, W.: Ruptur des Cysticusstumpfes nach Cholecystektomie. Zentralbl. Chir., **62**, 2779, 1935.

[11] Durst, H.: Zur Frage der Spontanruptur des Choledochus nach vorausgegangener Choledochusdraenage. Münch. med. Wchnschr., **83**, 801, 1936.

[12] Finney, J. M. T.: Surgery of the Bile Tracts. Surg. Clin. N. Amer., **16**, 1301, 1936.

[13] Haberer, H. von: Fragen aus dem Gebiete der Gallenwegchirurgie. Med. Welt, **8**, 1573, 1934.

[14] Heuer, G.: Surgical Treatment of Acute Cholecystitis. New York State Jour. Med., **36**, 1643, 1936.

[15] Hicken, N. F., Best, R. R., and Hunt, H. B.: Cholangiography—Visualization of the Gall Bladder and Bile Ducts During and After Operation. Annals of Surgery, **103**, 210, 1936.

[16] Jung: Cited by Demel, cit. 7.

[17] Karrillon: Cited by Smith, cit. 27.

[18] Mann, F. C., and Giordano, A. S.: The Bile Factor in Pancreatitis. Arch. Surg., **6**, 1, 1923.

[19] Mayo, W. J.: Surgery of the Hepatic and Common Bile Ducts. Lancet, **1**, 1299, 1923.

[20] McWilliams, C. A.: Acute Spontaneous Perforation of the Biliary System into the Free Peritoneal Cavity. Annals of Surgery, **55**, 235, 1912.

[21] Mirizzi, P. L.: Spaetruptur des Ductus choledochus. Zentralbl. Chir., **63**, 858, 1936.

[22] Mirizzi, P. L.: Technischer Fehler, erkannt durch die Cholangiographie wahrend der Operation. Stenose des Hepato-choledochus durch ligatur des Ductuscysticus. Zentralbl. Chir., **61**, 2857, 1934.

[23] Moynihan, B.: Secondary Operations upon the Biliary System. Lancet, **2**, 4, 1923.

[24] Popovici, A. N., and Ghimpetzeanu, M. U.: Verspaetete Rupture des Gallenblasenganges nach Cholecystektomie. Zentralbl. Chir., **63,** 2551, 1936.

[25] Popper, H. L.: Die Bedeutung des Erdringens von Pankreassaft in die Gallenwege. Bruns Beitr. z. klin. Chir., **164,** 125, 1936.

[26] Power, S.: Biliary Peritonitis. Brit. Med. Jour., **2,** 948, 1935.

[27] Robins, S. A., and Hermanson, L.: Cholangiography. Surg., Gynec., and Obstet., **62,** 684, 1936.

[28] Sherren, J.: Stone in the Common and Hepatic Ducts. Lancet, **2,** 7, 1923.

[29] Smith, W.: Rupture of an Intrahepatic Bile Duct with Fatal Peritonitis. ANNALS OF SURGERY, **33,** 55, 1926.

[30] Wolfson, W. L., and Levine, D. R.: Spontaneous Rupture of the Common Bile Duct. Surg., Gynec., and Obstet., **60,** 746, 1935.

[31] Mirizzi, P. L.: Diagnostico de la Litiasis del Hepatico y de Sus Ramas. Revista de Cirugia. 1937, August, p. 377.

DERMOID CYSTS OF THE MESENTERY

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DERMOID cysts of the mesentery are the rarest of all mesenteric tumors. While the latter are in themselves a rarity, a review of the literature reveals that there have been approximately 500 cases reported since the sixteenth century when Benivieni first described what is thought to have been a mesenteric tumor. Of these approximate 500 cases there have been less than a score of proved dermoid cysts of the mesentery reported. Cornils,[14] in 1920, reported eight cases of mesenteric cysts which he thought were true dermoids. The content of these tumors, however, was a fat-like substance, no hair or other ectodermal derivatives being found. On microscopic examination only an occasional area of what appeared to be plate-like epithelium was found. These findings cast considerable doubt upon the possibility of these cysts having been of dermoid nature. Forster,[15] in 1921, collected 16 cases from the literature, six of which (those of Eppinger, Spencer and Well, Koenig, Langhan, Schutzer and Marie) were undoubtedly true dermoids. The other ten fall under the same shadow of doubt as do those of Cornils. Montgomery and Morest[10] reviewed the literature in 1934 and found seven cases reported by Piermarini,[12] Sommer, Cortella,[13] Ugelli,[7] and Judd and Fulcher.[11] They also include one of Cornils' cases, bringing the previous number to eight. To this number they also add one observed by themselves. Of the two cases reported by Judd and Fulcher one was found to contain sebaceous-like debris but no ectodermal structures could be found on microscopic examination of its wall. If we can exclude the eight cases reported by Cornils, there remains a total of but 14 cases of proved dermoid cysts of the mesentery in the literature to the present date. The report of the fifteenth case is appended:

Case Report.—Hosp. No. C1787: F. McC., colored female, age two, was admitted to the Children's Hospital of Michigan March 8, 1937, with a history of having been perfectly well until three days previously when she rather suddenly experienced abdominal distress which was located definitely to the right side. At that time the mother first detected a mass in the right side of the abdomen. At the onset of the illness the temperature was thought to be elevated and the child soon became nauseated and vomited repeatedly. A cathartic was administered the following day which resulted in one or two evacuations after 24 hours; the abdominal distress and vomiting, however, had persisted to the time of admission.

Physical Examination revealed an intelligent, well-developed, colored girl apparently acutely ill. Other than for some dehydration and the abdominal findings, the general physical examination was essentially negative. There was moderate abdominal distension but no definite step-ladder effect, there were no visible peristalsis or masses apparent. On palpation, however, a mass could be made out in the right lower quadrant, which extended into the flank and as far medially as the midline. The tumor was tender,

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smooth and nonmovable. It could be readily felt by rectal examination. The left side of the abdomen was tympanitic throughout, but the right side was dull. A scout roentgenogram of the abdomen at this time revealed the right side of the abdominal cavity to be obscured by the mass which had pushed the bowel upward and to the left.

LABORATORY DATA.—Temperature was 100.6° F.; leukocytes, 13,500; 54 per cent polymorphonuclears and 46 per cent lymphocytes. Uranalysis was negative. Blood nonprotein nitrogen, 19.8 mg.; urea 6.3 mg.

The patient was treated for a low grade intestinal obstruction and responded well. There was considerable conjecture, however, as to the exact nature of the obstructing lesion.

Subsequent Preoperative Course.—On the day following admission intravenous pyelography was undertaken, which revealed a normal outline of the kidney pelves

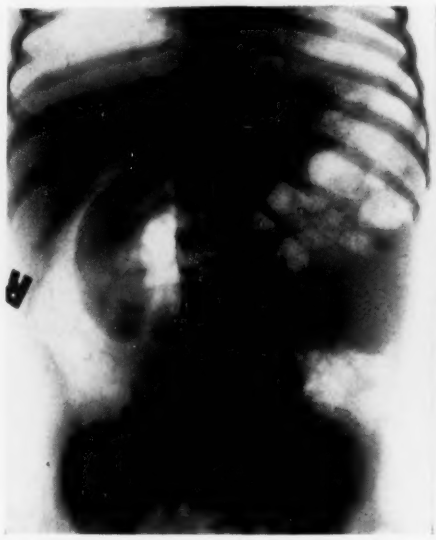

FIG. 1.—Anteroposterior roentgenogram of a right retroperitoneal air injection showing the normal right kidney well outlined by air. The round shadow in the midline below represents the cyst.

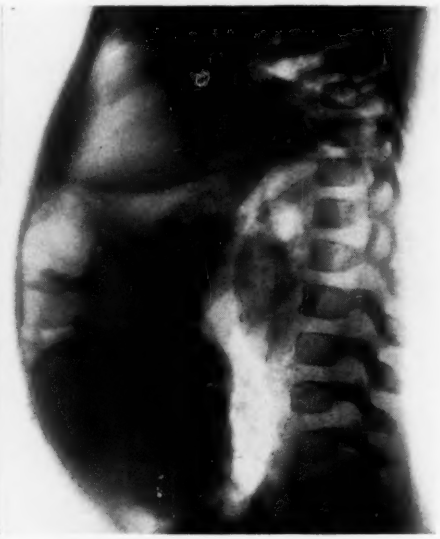

FIG. 2.—Lateral roentgenogram of retroperitoneal space as outlined by air injection. The normal right kidney may be seen well demarcated in the upper portion of the space with the dark shadow below representing the cyst.

without distortion of the kidney shadows. It was then felt that the mass was not related to the kidney, but some doubt was still present relative to the possibility of its being intraperitoneal. During the next few days the child continued to have daily elevations of temperature to 100° F., and to complain of persistent abdominal distress. On March 16, 1937, she was taken home against advice, but was returned two days later because of recurrence of the abdominal pain and repeated vomiting. On March 19, 1937, a retroperitoneal air injection was carried out, which resulted in an excellent outlining of the retroperitoneal space (Figs. 1 and 2). This definitely revealed the mass to have no relationship to the kidney and to lie anterior to the retroperitoneal space. The tumor also appeared to be smaller at this time and was movable within a short radius.

Operation.—March 20, 1937: Under ether anesthesia, an exploratory celiotomy was performed through a right rectus incision. A mass the size of a small grapefruit (Fig. 3) was found lying in the right lower quadrant. It arose from the mesentery of the lower ileum by a thick, short pedicle which appeared to have been twisted and to have undergone partial necrosis. The tumor encroached upon the ileum and was

adherent to it by recent adhesions. Simple excision of the tumor was effected by ligating the pedicle and breaking down the adhesions between it and the bowel. After removal of the mass the small rent in the mesentery at the base of the pedicle was repaired. The postoperative course was essentially uneventful and the child was discharged on the tenth postoperative day.

Follow-Up.—The patient has remained well to the present time. Gastro-intestinal roentgenologic studies, made June 28, 1937, showed: "No evidence of abnormality in contour or position of the stomach or of any loops of the small bowel; at four hours the head of the column was in the transverse colon; after 24 hours only a trace of barium remained in the rectum. The colon was empty, and there was no apparent displacement of its various segments."

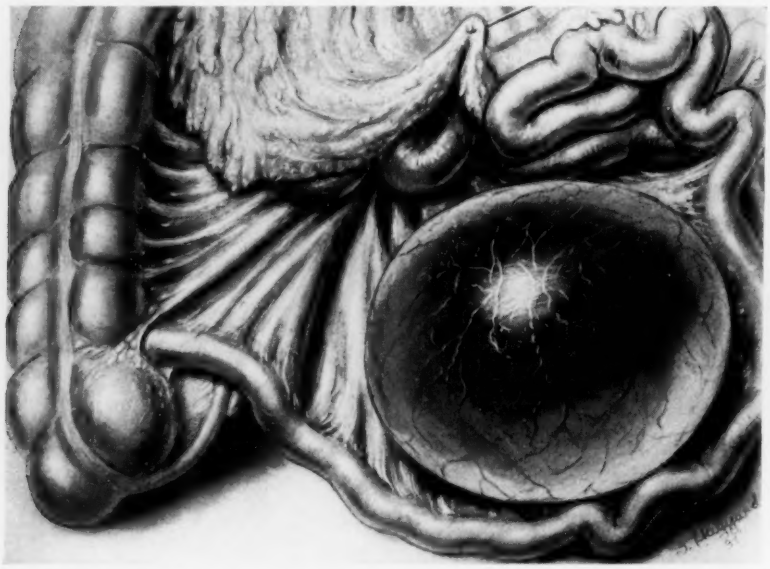

FIG. 3.—Drawing showing the relative size, position and anatomic relations of the mesenteric dermoid.

Pathologic Examination.—Gross: The tumor consisted of a tensely fluctuant mass measuring two and one-half by three inches (Fig. 4). It was opened on the side opposite the attachment of the pedicle, and was found to contain approximately 200 cc. of relatively fresh blood. The wall of the cystic portion measured one-third centimeter in thickness but at the pedicle this increased to one and one-half centimeters. It was on sectioning this region that hair and sebaceous material were found.

Microscopic Examination.—"The larger cystic areas are lined by stratified squamous epithelium, and the secondary skin characteristics are present. There are hair follicles and sweat glands present; in other sections, there are smaller areas which appear to be lined by columnar epithelium, about these areas mucous glands are seen, and two pieces of cartilage, similar to that seen about the bronchi, were encountered. There was a considerable amount of adipose issue; in the connective tissue trabeculae there were large numbers of thin-walled blood vessels; extravasated red blood cells were seen in the connective tissue. In some areas, the extravasation of these cells was so great that this tissue was necrotic." *Diagnosis:* Dermoid cyst of the mesentery.

DISCUSSION.—It seems most probable that the pedicle of this small dermoid became twisted, resulting in increased venous pressure within the thin-walled

vessels in the walls of the cysts, which resulted in a hemorrhage into one of them with the production of a large tumor mass which, in itself, was responsible for the incomplete intestinal obstruction. It is possible that had the patient not been operated upon at this time the mass might have receded to its former size. However, further twisting of the pedicle might have produced even greater increase in size with more complete intestinal obstruction or even rupture of the cyst.

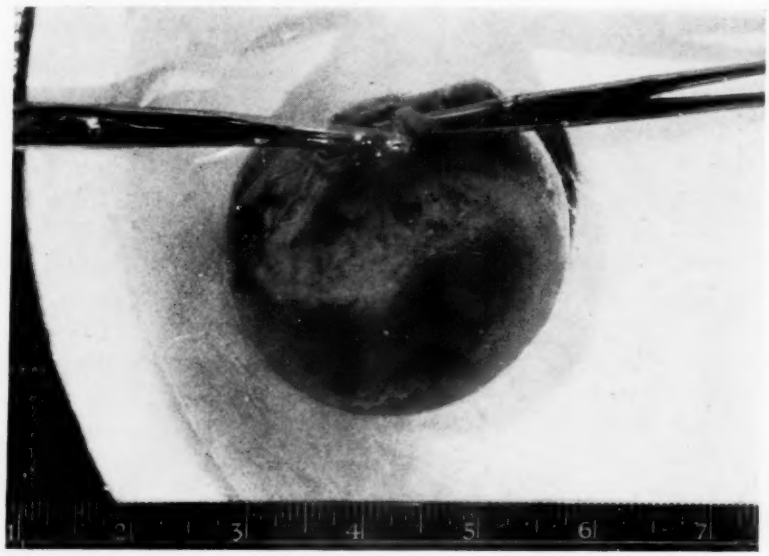

FIG. 4.—Photograph of the gross specimen of the mesenteric dermoid removed.

It is interesting to theorize upon the etiology of mesenteric dermoids. It is generally accepted that dermoids located elsewhere, in regions where they are more commonly observed, have their origin in ectodermal inclusions during closure of embryonal plates or fissures, or at the point of union of ectodermal and other structures. While this theory is quite adequate to explain those arising near the sites of union of embryonic fissures, such as the orbital region, branchial clefts and in the midline of the trunk, it does not seem adequate to explain those arising in the mesentery. It would seem more rational to believe that the cells of origin of these dermoids became sequestrated from their original habitat and wandered into the mesentery, not from the anterior abdominal wall, but from the retroperitoneal regions during the process of formation of the mesentery. Dowd,[2] and Lexer and Treutinger[17] are of the opinion that such cells might have been derived from the wolffian body or the mullerian tube. Ewing[16] feels that the majority of complex dermoids are imperfectly developed teratomata, and favors the theory of origin from sex cells. The exact distinction between teratomata and dermoids has, however, never been satisfactorily made. It seems reasonable to

believe that a gradation of embryonal tumors exists, and that the type of tumor which develops depends upon the potentialities of its original cell. Were this cell totipotent, a complex teratoma would result; were it multipotent, the result would be a dermoid, and were it unipotent, a simple tumor such as a myoma, fibroma or lipoma, would result. The correct solution of this problem has not as yet been arrived at.

The symptoms and signs of dermoids of the mesentery do not differ in any respects from those occasioned by other mesenteric tumors. There are no cardinal symptoms, all complaints resulting from purely mechanical disturbances. A gradually enlarging abdominal tumor may be noted, or its sudden appearance, as in the case cited, may first attract attention to the abdomen. The onset may be ushered in with intestinal obstruction of any degree. Severe pain is rare, being usually seen only in those cases having a pedicle of sufficient length to permit torsion. The signs are those of an abdominal tumor mass, which, however, may be overshadowed by any one of the possible complications, the most frequent of which is intestinal obstruction. Others are volvulus, intussusception, adhesions and, perhaps most rare, hemorrhage from one of the thin-walled vessels into the mesentery or the peritoneal cavity.

An exact diagnosis can be made only after celiotomy and subsequent microscopic examination of the cyst wall.

Treatment is entirely surgical. Simple enucleation, if possible, is the method of choice. If the tumor is of such size that its enucleation would embarrass the blood supply to the intestine, resection becomes necessary. Marsupialization, occasionally employed in the treatment of serous cysts of the mesentery, has never been undertaken in the treatment of mesenteric dermoids.

Prognosis following excision of the tumor is good. Recurrence, theoretically, is purely local and should carry no greater incidence than for dermoid tumors elsewhere in the body. There is no history of recurrence in any of the reported cases of proved dermoid cysts of the mesentery.

SUMMARY.—(1). A case of dermoid cyst of the mesentery treated by excision with recovery is reported, bringing the total number in the literature to 15.

(2). The patient, a girl, age two, is the youngest subject reported having such a tumor.

(3). The rarity of mesenteric dermoids is emphasized.

(4). The origin of these tumors is briefly discussed.

BIBLIOGRAPHY

[1] Bowers, L. G.: Tumors of the Mesentery. ANNALS OF SURGERY, **44**, 892, 1906.

[2] Dowd, C. N.: Mesenteric Cysts. ANNALS OF SURGERY, **32**, 515, 1900.

[3] Meyer, K., and Shapiro, P.: Dermoid Cyst of Lesser Omental Bursa. Am. Jour. Surg., **27**, 551, March, 1935.

[4] Steel, W. A.: Mesenteric Cyst as Cause of Intestinal Obstruction. Brit. Jour. Surg., **21**, 104, July, 1935.

[5] Kendall, A. W.: Mesenteric Tumour. Brit. Jour. Surg., **23**, 860, April, 1936.

[6] Phillips, H. A.: Spindle Celled Mesenteric Tumours. Brit. Jour. Surg., **21**, 637, April, 1934.
[7] Ugelli, Libero: Due Casi di cisti dermoidi det mesentere. Policlinico, **40**, 1534, 1933.
[8] Judd, E. S., and Crisp, W. W.: Primary Tumors of Mesentery. Proc. Staff Meeting Mayo Clinic, **7**, 555, September, 1932.
[9] Rankin, F. W., and Major, S. G.: Tumors of Mesentery. Surg., Gynec. and Obst., **55**, 244, May, 1932.
[10] Montgomery, J. G., and Morest, F. S.: Dermoid Cysts of the Mesentery. J. Missouri M. A., December, 1934.
[11] Judd, E. S., and Fulcher, O. H.: Dermoid Cysts of the Abdomen. Surg. Clin. N. Amer., **13**, 835, August, 1933.
[12] Piermarini, Giuseppe: Cisti dermoidi del mesentere. Riforma med., **41**, 1224, November 21, 1925.
[13] Cortella, Emilio: Cisti dermoidi del mesentere. Policlinico, **39**, 217, February 8, 1932.
[14] Cornils: Uber Dermoidcysten des Mesenteriums. Deutsche Zeitschrift fur Chirurgie, **153**, 399, 1920.
[15] Forster, E.: Ueber genuine Cysten des Mesenteriums. Beitrage zur klinischen Chirurgie, **124**, 116, 1921.
[16] Ewing, J.: Neoplastic Diseases, Third edition. Philadelphia, W. B. Saunders Co., 1934.
[17] Treutinger, J.: Dermoid im Netz bei kaiderseitegen dermoiden der Eierstocke. Arch. f. Gynak., **155**, 595, 1934.
[18] Fisher, W. H.: Mesenteric Tumors. Am. Jour. Surg., **7**, 803, 1929.

DIRECT INGUINAL HERNIA

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DIRECT inguinal hernia is that type of protrusion in which the hernial sac comes directly through the abdominal wall in contradistinction to indirect inguinal hernia in which the sac come obliquely through the abdominal wall by reason of its intimate association with the spermatic cord. The appearance of both of these otherwise dissimilar herniae at the external inguinal ring has led to their being grouped together for purposes of treatment. The poor results of operation for direct hernia are directly attributable to the employment of methods of repair which are satisfactory for indirect hernia, but are unsuitable for the direct variety because of the different problems involved. Recurrences after operation for direct inguinal hernia, judging from reports in the literature, vary from 6 to 50 per cent. It is instructive to note that the longer the time which had elapsed since operation and the more complete the follow-up, the greater was the number of recurrences. A review of our records in the Henry Ford Hospital reveals that during the decade 1920–1929, inclusive, we had 251 operations for direct hernia. We were able to trace 154 patients who were followed for a minimum period of two years after operation, and of these 18 had recurred, giving us a rate of recurrence of 11.6 per cent in direct hernia.

It has been customary to follow the teachings of Hamilton Russell and to designate a congenital origin to indirect inguinal hernia, and consider direct hernia as being of acquired origin. However, a consideration of the anatomic variations obtained in direct hernia suggests that the etiology of this type of rupture may also be explained on a congenital basis.

Surgical Anatomy of Direct Hernia.—The sac of a direct hernia pushes its way through the abdominal wall in an area designated as Hesselbach's triangle. The base of this triangle is formed by Poupart's ligament and the superior ramus of the pubes, its lateral boundary by the deep epigastric artery, and its medial boundary by the lateral edge of the rectus muscle and its sheath. The floor of the triangle is formed by the transversalis fascia. Next to the umbilicus, Hesselbach's triangle is the weakest spot in the abdominal parietes, lying as it does directly behind the external inguinal ring. It receives theoretic support from the peritoneum and preperitoneal fat posteriorly, and from the inconstant and attenuated conjoined tendon anteriorly. The floor of the triangle as viewed from the abdominal surface is seen to be divided into two unequal parts by a fold of peritoneum covering a fibrous cord which represents the obliterated hypogastric artery. The greater proportion, by far, of

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direct herniae comes through the larger medial compartment close to the pubic spine. Rarely the sac of a direct hernia protrudes through the smaller lateral compartment, constituting the so-called Hesselbach's hernia.

Anatomic Variations of the Inguinal Region in Direct Hernia.—The first anatomic variation that may be observed at operation on a direct hernia is the large size of the external inguinal ring in proportion to the size of the hernial sac. This point may be controversial since it might be claimed that the enlarged inguinal ring is secondary to the appearence of the hernia. However, it has been our observation, in following patients over a period of years, that those with large external inguinal rings frequently proceed to the development of direct hernia. The aponeurosis of the external oblique in cases of direct hernia is usually found to be intact and its fibers are not separated in the line of the inguinal canal, a condition that is so constant in oblique inguinal hernia. An examination of the rectus muscle after separation of the fibers of the external oblique aponeurosis, during the course of an operation for direct hernia, will commonly reveal three definite departures from the normal. The body of the muscle itself is much narrower than usual. The fleshy fibers of the internal oblique and transversalis muscles arch upwards to unite at the lateral edge of the rectus muscle and appear to be inserted directly into the anterior sheath of the rectus muscle rather than through the intermediary of a fibrous tendon. The conjoined tendon is rudimentary or absent. It will be noted that these three factors deprive the weak area of the abdominal wall of additional support and thus render it more vulnerable and prone to hernial formation. It is true that nature recognizes the weakness and makes a futile effort to remedy it by causing the cremaster muscle to hypertrophy and cover over the defect. Inasmuch as these variations may be said to be congenital, it is maintained that there is some justification for suggesting that direct hernia has a congenital origin.

Diagnosis.—The clinical diagnosis of direct inguinal hernia is not especially difficult in spite of the frequent assertion that differentiation between direct and indirect hernia can sometimes be made only at operation. It is essential to give consideration to certain points in the history and clinical examination if the observer is to arrive at a correct conclusion in the majority of cases. Direct hernia is a condition which appears in middle age at the time of life when there is a decrease in muscular tone, and fibrous tissue loses its elasticity. This relationship between loss of muscle tone and direct hernia is well exemplified in emaciated individuals and in those suffering from debilitating diseases. The subjects of direct hernia are usually adult males, though occasionally the condition exists in women or children.

The onset is often so gradual that a moderate sized hernia will develop without the individual's knowledge. Pain, therefore, is a rare symptom of direct hernia in contradistinction to the usual traumatic history obtained in indirect inguinal herniae.

Direct hernia is frequently bilateral, and while this is also true of indirect inguinal hernia, there is this difference, that in the former, both sides tend

to appear simultaneously while in the latter there is often an interval between the appearance of the hernia on the two sides.

Occupation also has a bearing on the differential diagnosis. If we take for example a man who has been engaged in heavy labor since early adult life, the hernia which he develops at age 45 is more likely to be direct, for if he has been possessed of the preformed sac of an indirect hernia, the hazards of his occupation must have provided, on many occasions, the extra strain necessary to force down the abdominal contents and produce clinical evidence of hernia.

The nature of a hernia can be readily defined by observing the passage of the contents of the sac through the abdominal wall. The patient should be standing in a good light in order to determine whether the sac comes straight through the abdominal wall, as in direct hernia, or obliquely through, as in indirect hernia. The incorporation of the sac of an indirect hernia in the coverings of the spermatic cord permits the sac and its contents to follow this structure to the upper pole of the testes so that even a moderate sized indirect inguinal hernia is found in the scrotum. The sac of a direct hernia, regardless of its size, since it has no relationship with the spermatic cord, cannot enter the scrotum. The bulging of a large direct hernia may encroach on the skin of the scrotum but the sac does not enter the scrotal cavity. Direct herniae appear instantly when the patient assumes the erect position and are as rapidly reduced when the recumbent position is resumed, whereas, in indirect hernia there is usually some delay in the appearance and in the reduction of the hernia. The larger mouth and more direct course of the sac explain this difference and account for the comparative rarity of incarceration of a direct hernia.

The clinical appearance of a direct hernia depends primarily on a defect in the transversalis fascia. This structure, in patients who develop direct hernia, provides practically the only barrier against protrusion of peritoneum through the abdominal wall. The additional strain thrown on the transversalis fascia by loss of muscle tone of the abdominal wall, by increased intra-abdominal pressure or by the laying down of preperitoneal fat in large amounts, causes stretching and ultimate rupture of its fibers. A break in the continuity of the transversalis fascia can be brought about by trauma as is well evidenced by the practice of inducing hernia by this method in conscripts who seek to avoid military service. The clinical diagnosis of direct hernia depends, to a large extent, on an examination of the floor of Hesselbach's triangle. After inspection of the inguinal region in the erect position, to determine if possible the direction of the passage of the hernial sac through the abdominal wall and to observe the relation of the sac to the scrotal cavity, the patient should be put in the recumbent position. An investigation of the integrity of the floor of Hesselbach's triangle is carried out by invaginating the elastic wall of the scrotum through the enlarged external inguinal ring. If the tip of the examining finger encounters no resistance, the impression is given of passing directly into the pelvic cavity, and it can, therefore, be

assumed that the transversalis fascia is disrupted and that we are dealing with a direct hernia. It is also possible, in most instances, to palpate, above and medially, the sharp lateral edge of the rectus sheath, and below, the smooth superior ramus of the pubic bone. In some very large indirect inguinal herniae of long standing, Hesselbach's triangle may be so much encroached upon as to present similar findings, but then the fact that the hernial sac enters the scrotal cavity serves as the differential diagnostic point. Stiles, of Edinburgh, was frequently able to diagnose an indirect inguinal hernia by determining the presence of a sac from palpation of the structure of the spermatic cord in the scrotum.

Incidence.—In a recently reported series of 1,600 hernia operations performed at this hospital during the decade 1920–1929, the proportion of direct herniae was 15.7 per cent. However, at the present time, the figures closely approximate 25 per cent. This increase is due, in part at least, to more rigid preemployment examinations which result in the rejection of an increasing number of workmen with small inguinal herniae. These men are now obliged to undergo operation in order to obtain work, and it is in this group of cases that we have observed an increased proportion of direct herniae, more especially when the condition is bilateral.

Operative Technic.—The repair of a direct hernia is essentially a plastic operation, the success of which depends on adherence to the cardinal rules of plastic surgery: namely, utilization of all available tissue to the best advantage and suturing without tension. The medial extremity of the usual hernial incision should extend well over the external inguinal ring to provide adequate exposure of the pubic spine and to allow enough retraction of the medial flap of the external oblique aponeurosis to expose the rectus muscle and sheath. The hockey-stick incision will be found useful in obese patients. The fibers of the external oblique aponeurosis are separated in line with the upper pillar of the external inguinal ring so as to prepare a large lateral flap for subsequent imbrication. The ilio-inguinal nerve is identified and isolated for protection, before incising the cremaster muscle and fascia. The structures constituting the spermatic cord are then shelled out of their enveloping cremasteric fibers for the entire length of the canal and isolated by tape. The fat covered direct sac is now well exposed lying in the medial half of the canal, and the diagnosis of direct hernia substantiated by the fact that the sac lies entirely free of the spermatic cord and is not incorporated in its structures (Fig. 1).

The sac is best opened in the manner advocated by Hoguet,[4] whose contribution constitutes a real advance in the treatment of direct hernia. The tediousness of the dissection necessary to open and free the direct sac and the constant anxiety regarding possible bladder injury are entirely obviated by adopting Hoguet's maneuver which is as follows: The internal inguinal ring is exposed by gentle traction on the spermatic cord and by retraction of the internal oblique and the transversalis muscle with a vein retractor. A careful inspection of the posterior internal aspect of the cord will reveal the crescentic peritoneal border of the potential indirect inguinal hernia sac, a

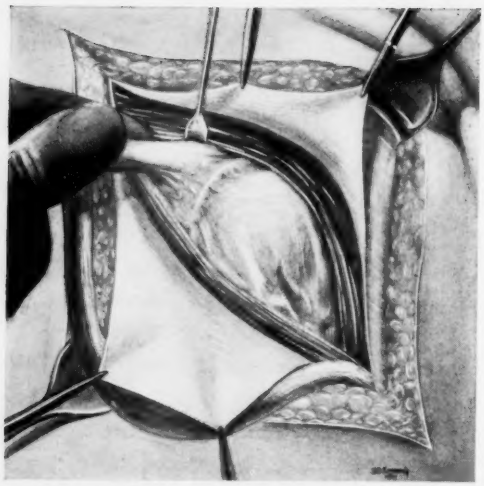

FIG. 1.—The direct sac is shown in Hesselbach's triangle medial to the deep epigastric vessels. The region of the internal ring is displayed and the spermatic cord elevated to show the potential indirect sac on its postero-internal aspect.

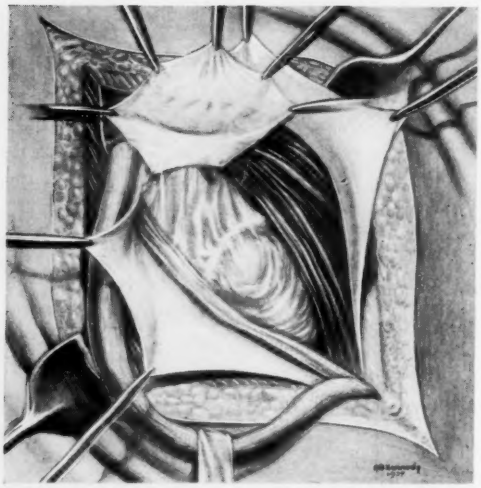

FIG. 2.—The potential indirect sac has been separated from the spermatic cord, freed from the peritoneal fat at its neck and opened.

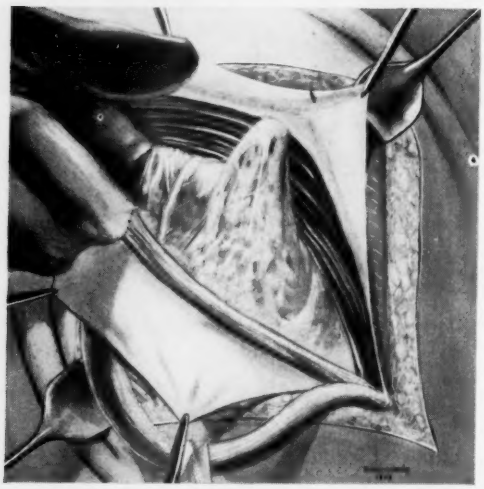

FIG. 3.—The surgeon's index finger has been passed into the peritoneal cavity through the opened potential indirect sac and directed medially to enter the mouth of the sac.

structure which is constantly present in close association with the vas (Fig. 2). The peritoneal cavity is opened here by picking up and incising the potential sac after separating the fibers of the internal spermatic fascia. An examining finger now enters the peritoneal cavity and is directed medially behind the deep epigastric vessels to enter the mouth of the direct sac and verify the diagnosis (Fig. 3). Traction is now put on the small indirect sac, and by brushing away the preperitoneal fat and bringing into view first the deep epigastric vessels, and the fibrous cord of the obliterated hypogastric artery, until the bladder is drawn up in the wound, it will be found that the direct sac now lies lateral to the deep epigastric vessels and that the two sacs have been converted into one wide-mouthed indirect sac (Fig. 4). Closure of the sac is now effected by a purse string suture inserted from within. This method of dealing with the sac entirely guards against overlooking a saddle bag hernia and, since it is admitted that failure to recognize and remove both sacs is a frequent cause of recurrence, this feature alone commends its use.

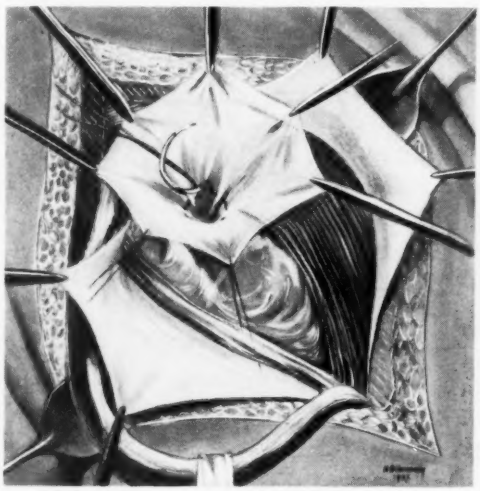

FIG. 4.—The lax peritoneum of the direct sac has been pulled up from underneath the deep epigastric vessels after brushing away the preperitoneal fat, and the direct hernia is now "converted" into a indirect hernia. It is closed by a purse string suture inserted from within the sac.

Since the appearance of a direct hernia depends primarily upon a break in continuity of the transversalis fascia, it follows that repair of this structure must be the most important step in the operation. It is absolutely essential to identify the course of the deep epigastric vessel before proceeding with suture of the transversalis fascia if troublesome hemorrhage is to be avoided. In small direct herniae, where there is simply a stretching and thinning out of the fibers of the fascia, a purse string suture or series of purse string sutures will suffice to close the defect. Rarely in addition to a generalized bulging is there a definite small opening in the transversalis fascia with a protrusion of preperitoneal fat or even a small fat-covered secondary sac, the so-called diverticulum described by Andrews.[1] It is important in these cases to reduce the contents and suture this opening before proceeding with the usual repair. In the majority of direct herniae, however, there is complete separation, or attenuation, of the fibers of the transversalis fascia, from the pubic spine to the internal ring. It is necessary at this stage to retract the rectus muscle strongly and bring into view the transversalis fascia which in this region is of surprising strength, because here it takes the place of the deficient posterior rectus sheath. It is easily recognized as a strong aponeu-

rotic sheet which may be adequately mobilized to permit its suture to the shelving edge of Poupart's ligament, from the pubic spine to the internal inguinal ring (Fig. 5). Special care should be taken in suturing the medial half because this is the critical area where recurrence takes place. It is usually necessary to divide the remnants of the cremaster muscle in order to effect complete apposition of the transversalis fascia to the medial half of Poupart's ligament.

When the first line of defense against recurrence is completed, the question of support arises. It is apparent, that in the majority of cases the usual Bassini operation must be doomed to failure because of the difficulty of closing the defect. It will be found impossible in many instances to approximate the arching fibers of the internal oblique and transversalis muscles to Poupart's ligament, and even in those cases in which apposition can be made, the sutures are tied under tension, thereby violating the first principle of plastic repair. Numerous efforts have been made to solve the problem of closing in this triangle. Bloodgood opened the lateral margin of the rectus sheath and brought down the fleshy fibers of the muscle to Poupart's ligament, and Halsted turned down a flap of anterior rectus sheath, but the late results of these modifications were not good. Gallie's effort to close the defect by weaving in strips of fascia lata has proved effective, and while it has a definite place when the structures are poor and in the repair of recurrent hernia, disadvantages such as tediousness and increased risk of infection prevent its universal adoption. Free fascial grafts have been employed with indifferent results. A solution of the problem of obtaining adequate tissue to close the defect without tension on the sutures is found in a modification of the device suggested by Downes,[2] who advocated opening the rectus sheath by an incision just internal to its lateral margin and then bringing the fibers of the rectus muscle down to Poupart's ligament. The second part of this step has all the disadvantages of the Bloodgood and Halsted procedures and may be omitted by making a more medial incision in the rectus sheath. The aponeurosis of the external oblique has a loose attachment to the rectus sheath at its lower end and actually has its main insertion close to the midline. Advantage is taken of this loose attachment to separate the external oblique aponeurosis from the rectus sheath by sharp dissection. It will now be found that the anterior rectus sheath, which in reality is composed of the conjoined tendon of the internal oblique and transversalis muscles, is exposed almost to the midline. The incision of the sheath is made in a vertical direction as close as possible to the reflection of the aponeurosis of the external oblique and extends from the pubic crest upwards for a distance of from two and one-half to three inches. A muscular branch of the deep epigastric artery is almost always severed, but bleeding is easily controlled by a transfixion suture. The firm, fibrous lateral edge of the rectus muscle and sheath is now easily approximated to Poupart's ligament without tension. The first interrupted suture is introduced at the lower angle and includes the periosteum over the

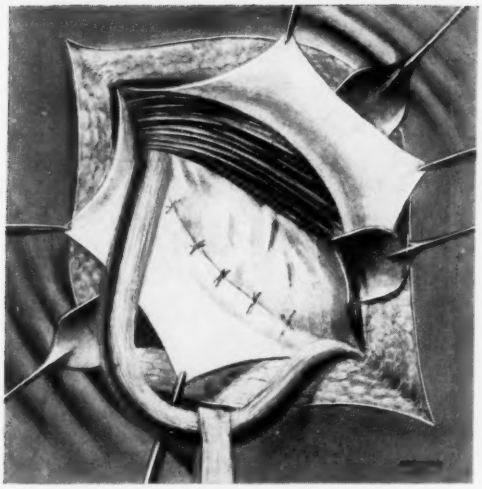

FIG. 5.—The transversalis fascia has been mobilized and sutured to Poupart's ligament.

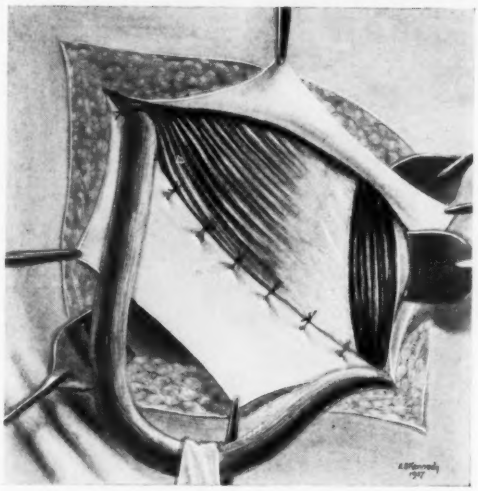

FIG. 6.—The lateral margin of the rectus muscle and sheath and margin of the internal oblique and transversalis muscle have been sutured to Poupart's ligament. Note the wide gap in the anterior rectus sheath.

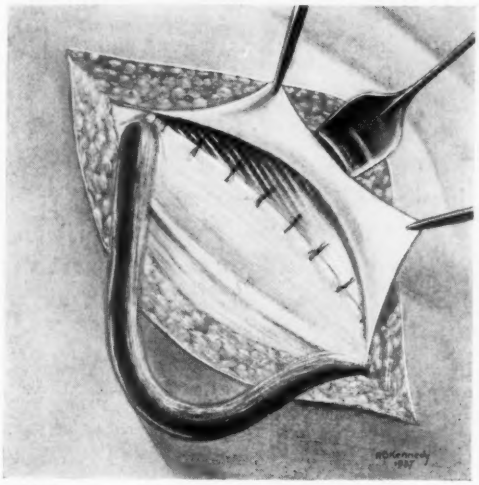

FIG. 7.—The lateral flap of the external oblique aponeurosis has been sutured to the anterior surface of the internal oblique and rectus muscles. Note the incision opposite the internal ring.

pubic spine. The suturing is continued up to the internal inguinal ring and one or two sutures are placed above the spermatic cord, care being taken not to include the ileo-inguinal nerve (Fig. 6). The triangle defect is thus adequately closed by a firm fibromuscular bundle without weakening the abdominal wall, for the gap which now exists in the anterior rectus sheath is amply protected by the fleshy fibers of the rectus muscle posteriorly and the aponeurosis of the external oblique anteriorly.

Additional support is rendered by modifying the classic Bassini technic and imbricating the aponeurosis of the external oblique behind the spermatic cord. The lateral flap of the external oblique which has purposefully been fashioned as large as possible is now sutured down to the anterior rectus sheath and internal oblique muscles with interrupted sutures. This lower flap is incised opposite the internal inguinal ring, in order that the spermatic cord may not be subjected to pressure and the viability of the testes endangered (Fig. 7). The medial flap of external oblique aponeurosis is now sutured down to the external aspect of Poupart's ligament for the whole length of the canal. One or two sutures are placed above the point where the cord emerges, thus forming a new external inguinal ring (Fig. 8). The external inguinal ring is now superimposed on the internal ring, but in our experience this does not predispose to recurrence if a high closure of the sac has been effected. The operation is now completed by allowing the cord to fall back upon the surface of the external oblique and closing the subcutaneous tissues and skin over it.

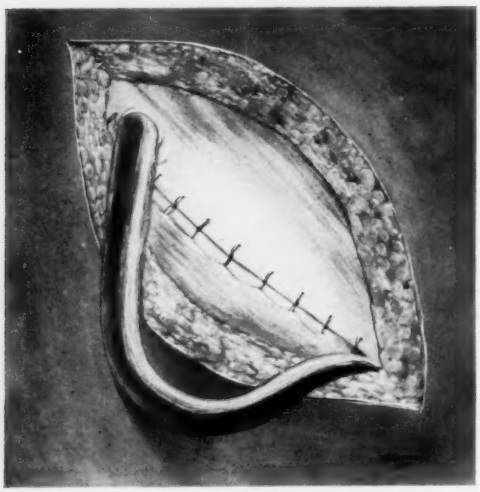

FIG. 8.—The medial flap of external oblique aponeurosis is sutured down to Poupart's ligament behind the cord and a new external ring has been fashioned.

SUMMARY AND CONCLUSIONS

(1) The surgical anatomy of the inguinal region concerned with direct hernia is briefly reviewed.

(2) An attempt is made to attribute a congenital origin to direct hernia on the basis of certain constant anatomic variations.

(3) The diagnosis of direct hernia rests upon the recognition of two facts: First, that the sac has no relationship to the spermatic cord; and second, that there must be a separation or stretching of the fibers of the transversalis fascia.

(4) The cure of direct hernia is essentially a plastic operation. A method of repair in which the transversalis fascia is utilized and the defect in Hesselbach's triangle is further reinforced by a fibromuscular bundle derived from the rectus muscle and sheath is described.

REFERENCES

[1] Andrews, E., and Bissell, A. D.: Direct Hernia: Record of Surgical Failures. Surg., Gynec., and Obst., **58,** 753–761, April, 1934.

[2] Downes, W. A.: Management of Direct Inguinal Hernia. Arch. Surg., **1,** 53–73, July, 1920.

[3] Fallis, L. S.: Inguinal Hernia. ANNALS OF SURGERY, **104,** 403–418, September, 1936.

[4] Hoguet, J. P.: Direct Inguinal Hernia. ANNALS OF SURGERY, **72,** 671–674, December, 1920.

[5] Hotchkiss, L. W.: Observations on Treatment of Direct Inguinal Hernia in Adults. ANNALS OF SURGERY, **68,** 214–216, August, 1918.

[6] Hutchins, E. H.: Operation for Direct Inguinal Hernia. Surg., Gynec., and Obst., **54,** 964–968, June, 1932.

[7] Partipilo, A. V.: Direct Inguinal Hernia Incident to Indirect Hernia; Method of Detection and Repair. Am. Jour. Surg., **7,** 99–102, July, 1929.

[8] Taylor, A. S.: Results of Operations for Inguinal Hernia. Arch. Surg., **1,** 382–406, September, 1920.

[9] Watson, L. F.: Hernia. St. Louis, C. V. Mosby Co., 1924.

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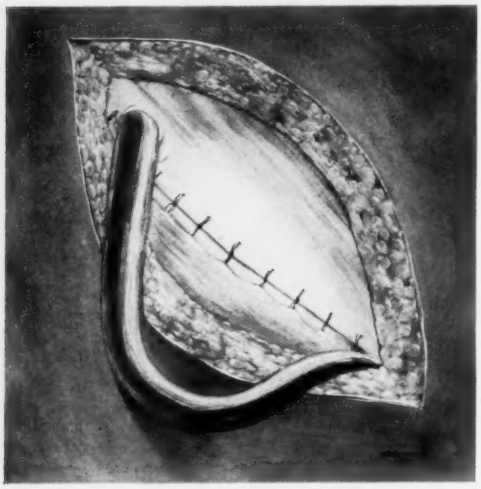

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REFERENCES

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[2] Downes, W. A.: Management of Direct Inguinal Hernia. Arch. Surg., **1,** 53–73, July, 1920.

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[8] Taylor, A. S.: Results of Operations for Inguinal Hernia. Arch. Surg., **1,** 382–406, September, 1920.

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THE COMMUNICATING VEINS OF THE LOWER LEG AND THE OPERATIVE TECHNIC FOR THEIR LIGATION

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THE superficial venous systems of the lower leg, the long and short saphenous veins, are connected directly with the deep venous systems, the posterior tibial, anterior tibial, peroneal and popliteal veins by a series of communicating veins. These vessels are not to be confused with the perforating veins that actually pass through the deep fascia. The following distinctions should be made between them: The former are the main venous trunks which join directly with the deep veins. They extend inward along the intermuscular fascial planes from the outer surface of the muscles. The latter, on the other hand, are the vessels which actually pass through the deep fascia and connect with the superficial veins.[1] In many instances the perforating veins may be a direct continuation of the communicating veins, but frequently several of them may unite beneath the deep fascia to form one of the latter. Occasionally veins will be found that drain blood from the muscles through the deep fascia to the superficial venous systems (Fig. 2). Since this type of vein does not directly connect the deep and superficial venous systems it is not a communicating vein, but on the other hand it should be termed a perforating vein. The communicating vessels also present more constant anatomic relations, that is, they are found along definite intermuscular septa, while the perforating veins vary considerably in the points at which they pass through the deep fascia (compare Figs. 1 and 2).

In the normal state the communicating veins have valves which permit the blood to pass only from the superficial to the deep systems. In many cases of varicose veins, especially those following deep phlebitis, these valves become incompetent, allowing blood to flow in either direction. This abnormal condition often is associated with varicose ulcers. To effect a cure in such cases it is necessary to interrupt the communicating veins in addition to performing a ligation and injection of the involved saphenous systems, according to the method that has been described by Faxon.[2]

The best description of the communicating veins in the lower leg was given by von Loder,[4] a Russian anatomist, in 1803. Since then very little has been added to the anatomy of these veins. Both Rémy,[5] in 1901, and Meisen,[6] in 1932, reproduced Loder's drawings in their books on varicose veins to show the usual distribution of the communicating veins in the lower leg. However, the descriptions by these men, also the ones by Braune[1] and Klotz,[3] and those in the standard textbooks of anatomy were found to be incomplete.

Since a more accurate knowledge of these veins was found necessary for the proper treatment of varicose veins and ulcers, a study of them has been carried out. The purpose of this paper is to describe: (1) The anatomic relations

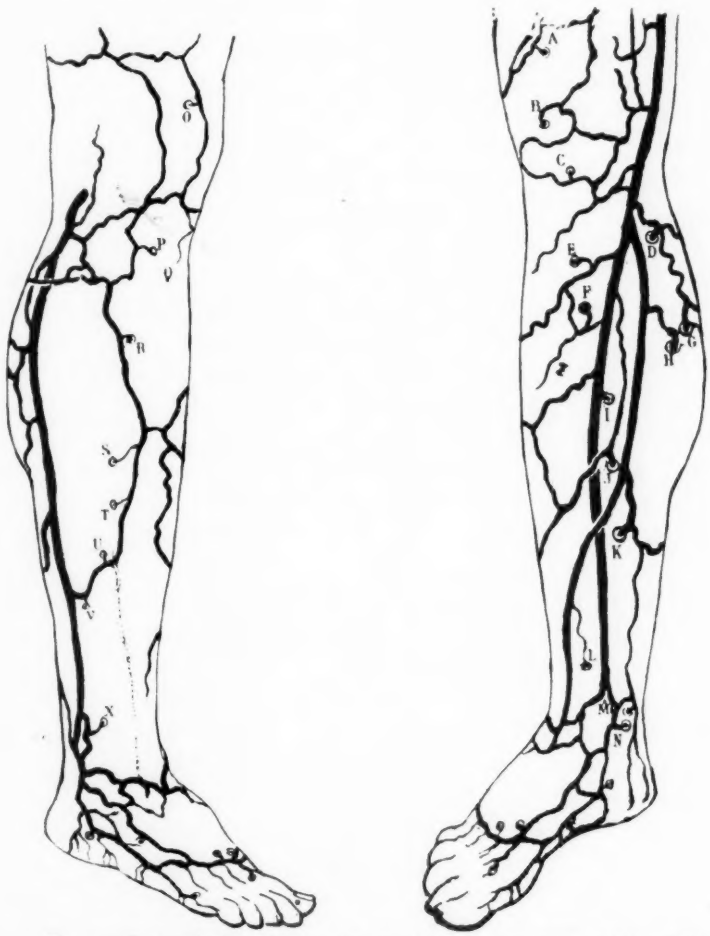

FIG. 1.—Communications (perforating veins) to the deep veins on the medial and lateral surfaces of the leg (after Loder according to Rémy[5]). They are represented by the letters enclosed within circles. Note that the dissections in these specimens are on the superficial aspect of the deep fascia while in Figs. 2, 3 and 4 they are beneath the deep fascia.

of the communicating veins of the lower leg; and (2) the operative technic for their ligation.

Anatomy.—The following anatomic facts are based upon data from the dissections of ten lower legs and on the findings in a series of 50 operations for the ligation of the communicating veins. In the dissected specimens, all of the veins of the leg were injected through one of the superficial veins over the dorsum of the foot. A suspension of barium sulphate in water was employed. The veins became filled with the white barium salt which made them readily visualized during the dissection.

The communicating veins of the lower leg connect the long and short saphenous systems with the posterior tibial, the anterior tibial, peroneal and popliteal veins. They may occur singly or in pairs. It was found that there is a fairly constant number of them in the lower leg and that they present definite relations to the other structures of the leg. In the normal state they are thin-walled and vary from a fraction of a millimeter to about 2 Mm. in diameter. When incompetent they are thick-walled and it is not uncommon to find them .5 cm. in diameter.

For descriptive purposes they have been divided into the posterior tibial, anterior tibial, peroneal, and popliteal groups.

The Posterior Tibial Communicating Veins.—This series of veins is found on the inner or medial aspect of the lower leg (Fig. 2). They arise from either of the posterior tibial veins, the uppermost ones being found about the middle of the proximal third of the lower leg. They pass outward along the intermuscular septum between the flexor digitorum longus and the soleus muscles, passing through some of the fibers of the latter near its attachment to the posteromedial edge of the tibia. They frequently arise as double veins and as they approach the deep fascia, may unite to form one trunk and then break up into a variable number of branches. Some of these pass to adjacent muscles while others perforate the overlying deep fascia to connect with the long saphenous vein or its tributaries. There are usually two sets of these veins in this portion of the lower leg (Fig. 2).

In the middle third of the lower leg one or two sets of communicating veins are found. These arise and pass outward in a similar manner to the previous ones except that they do not pass through the soleus muscle since they arise below its origin to the tibia. In the distal third of the leg there are three or four communicating veins. The lowest one lies at the level of the lower border of the malleolus and posterior to it. The upper ones pass outward along lamina profunda of the deep fascia of the leg which separates the posterior tibial vessels and nerve, the flexor digitorum longus and tibialis posticus muscles and their tendons, from the soleus muscle and the Achilles tendon (Figs. 2 and 5). Usually they perforate the deep fascia posterior to the posteromedial edge of the tibia and pass forward to join the long saphenous vein over the crest of the tibia.

The Anterior Tibial Communicating Veins.—These vessels arise from the anterior tibial veins and communicate with both the long and short saphenous systems, but chiefly with the former. They are found on the anteromedial, anterior, and anterolateral surfaces of the lower leg. They should be divided into three subdivisions: the medial, the central and the lateral. The medial one consists of three or four small paired veins which are normally about 0.5 Mm. in diameter. They are found in the middle two-thirds of the lower leg and pass posterior to the tibialis anticus muscle and the tibia, after passing through the interosseous membrane. They extend forward on the inner aspect of that bone in very close association with the periosteum (Figs.

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FIG. 2

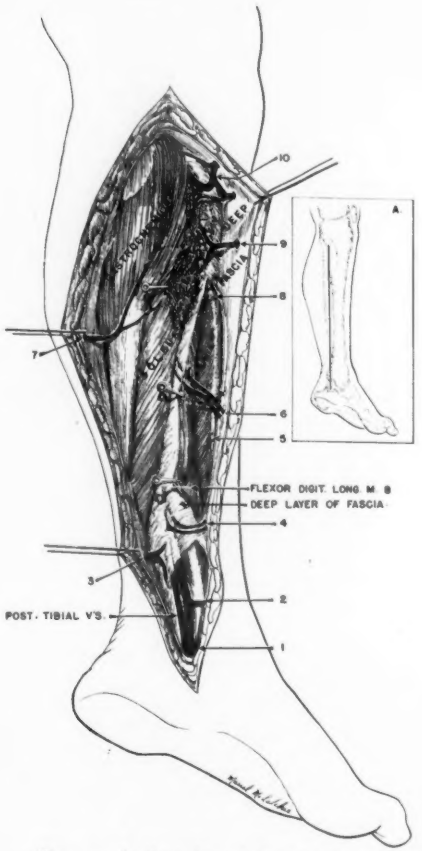
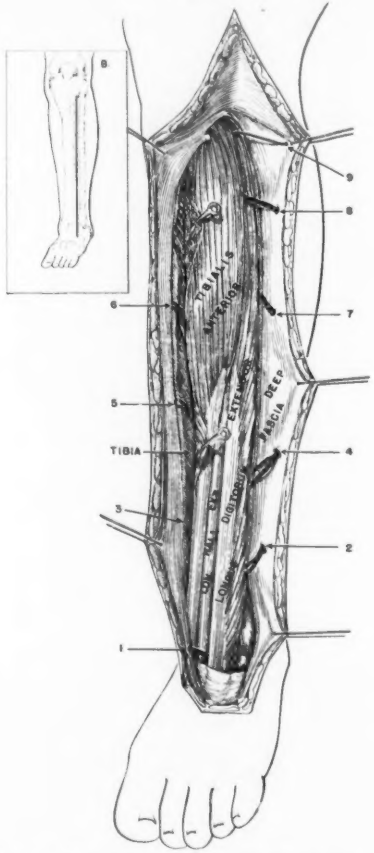


FIG. 3



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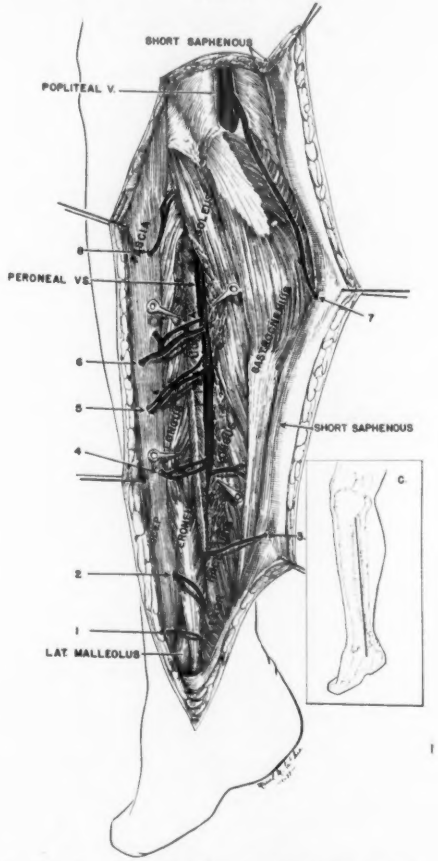

FIG. 2.—A dissection of the medial aspect of the lower leg to show the medial group of communicating veins. The deep fascia has been divided longitudinally on the medial side of the lower leg posterior to the tibia, and dissected from the muscles both anteriorly and posteriorly. In the upper portion of the leg the soleus muscle has been partially divided. In the lower half the lamina profunda of the deep fascia has been cut exposing the posterior tibial artery and veins, and the flexor digitorum longus muscle. The latter muscle has been retracted to expose the medial side of the tibia. Nos. 1, 2, 3, 4, 6, 9 and 10 are posterior tibial communicating veins. Nos. 5 and 8 belong to the medial subdivision of the anterior tibial communicating veins. No. 7 represents a perforating vein which drains blood from the muscle through the deep fascia to the superficial veins. The inset shows the incision used in the operation for the ligation of these veins.

FIG. 3.—A dissection of the anterior aspect of the lower leg to show the anterior group of communicating veins. The deep fascia has been divided longitudinally midway between the tibia and fibula on the anterolateral surface of the lower leg, and the anterior peroneal intermuscular septum incised to show the lateral subdivision of the anterior tibial communicating veins, Nos. 1, 2, 4, 7, 8 and 9. The tibialis anticus muscle is retracted laterally to show the central subdivision, Nos. 3, 5 and 6 on the lateral aspect of the tibia. The inset shows the incision used in the operation for the ligation of these veins.

FIG. 4.—A dissection of the posterolateral aspect of the lower leg to show the lateral group of communicating veins. The deep fascia has been divided longitudinally on the posterolateral aspect of the lower leg posterior to the fibula. The dissection has been carried down along the posterior peroneal intermuscular septum to the peroneal veins and shows the peroneal communicating veins, Nos. 1, 2, 3, 4, 5, 6 and 8. Posteriorly, the deep fascia has been elevated to show the popliteal communicating vein, No. 7. The short saphenous vein is shown superficial to the deep fascia with communicating veins Nos. 3 and 7.

2 and 5), and perforate the deep fascia over the anteromedial surface of the tibia to join the long saphenous system of veins.

The central subdivision consists of a series of veins similar to the first except that they pass only posterior to the tibialis anticus muscle and then run forward on the lateral surface of the tibia (Figs. 3 and 5). They perforate the deep fascia just at the outer edge of the tibia to anastomose with the superficial veins. In the dissections and at the operations, the veins of these two subdivisions were very rarely found to be enlarged or incompetent, but since these veins may be involved and as they are always present, they should be exposed at operation.

The lateral subdivision consists of a series of larger communicating veins which are found on the anterolateral surface of the leg. There are five to six in this group. The highest one lies a short distance below the head of the fibula. The upper one or two veins pass outward between the tibialis anticus and extensor digitorum longus muscles. The others except for the lowest one come out along the anterior (peroneal) intermuscular septum between the extensor digitorum longus and the peroneus longus muscles (Fig. 5). The most distal one of this subdivision emerges between the tendons of the extensor hallucis longus and extensor digitorum muscles just above the annular ligament of the ankle joint (Fig. 3). These veins anastomose with the superficial veins in this region that may be tributaries of either the long or short saphenous veins.

The Peroneal Communicating Veins.—The vessels in this group arise from the peroneal veins and connect them with the short saphenous system on the posterolateral surface of the leg (Fig. 4). They vary from six to seven in number. The uppermost one is found about 2 or 3 cm. below the head of the fibula and the lowest at the level of the lateral malleolus. In the upper one-half of the lower leg they emerge along the intermuscular septum which separates the peroneus longus and soleus muscles (Fig. 5). They give off a number of muscular tributaries as well as perforating branches. In the lower one-half they pass outward between the peroneus longus and flexor hallucis longus muscles.

The Popliteal Communicating Vein.—This vein is not a constant finding but frequently it is present. It arises from the popliteal vein between the two heads of the gastrocnemius muscle and descends with the lateral division of the sural nerve to about the upper part of the middle third of the leg. It pierces the fascia at this level to join the short saphenous vein after giving off a number of branches to the gastrocnemius muscle (Fig. 4.) Frequently the vein which perforates the fascia at this point arises directly from the gastrocnemius muscle and simply drains blood from it into the short saphenous vein. In such cases it is not a true communicating vein.

Operative Technic.—The communicating veins have been divided into three main groups: the medial, the anterior and the lateral, to facilitate their surgical exposure. The medial group is found on the inner side of the lower leg. It consists of the posterior tibial and the medial subdivision of the

anterior tibial communicating veins. The anterior group is on the anterolateral surface of the lower leg. It is made up of the central and lateral subdivisions of the anterior tibial communicating veins. The lateral group is situated on the posterolateral surface of the lower leg and consists of the peroneal and popliteal communicating veins.

Preoperative Preparation.—The skin and subcutaneous tissues of the lower leg in cases of incompetent communicating veins often are edematous and present a chronic infection or ulceration. Operation should not be performed until the edema and infection have disappeared and the ulceration healed for six weeks. This is accomplished by placing the patient in bed and elevating

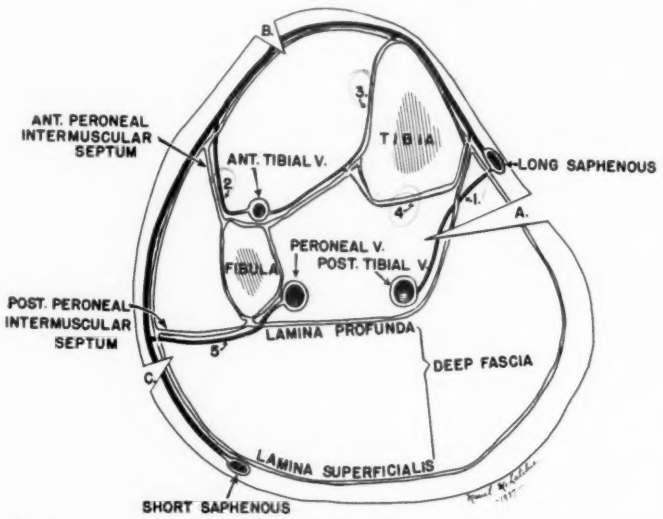

FIG. 5.—A diagrammatic drawing of a cross section of the lower leg at the junction of the lower and middle thirds, to show the relationships of the communicating veins to the deep fascia and the intermuscular septa. No. 1 represents a posterior tibial communicating vein. Nos. 2, 3 and 4 represent communicating veins respectively of the lateral, central and medial subdivisions of the anterior tibial communicating veins. No. 5 represents a peroneal communicating vein. Letters A, B and C show respectively the locations of the operative incisions for the medial, anterior and lateral groups of communicating veins.

the affected extremity on pillows so that it rests on a level slightly above that of the heart. If the ulcer is a large one, healing will be hastened by covering it with a large "Thiersch" skin graft. This will grow rapidly and survive as long as the leg is kept in an elevated position or securely bandaged. All open lesions should be cultured for the hemolytic streptococcus. If it is present, grafting should be delayed until this organism has been eradicated with moist dressings.

In addition to bacterial infections, the skin in the lower leg may present an itchy vesicular rash. This is due to a fungus infection. It rapidly clears up with daily applications of a solution containing one-tenth of 1 per cent thymol and 2 per cent each of resorcinol and benzoic acid in 95 per cent ethyl alcohol.

After all ulcerations are healed and the infection cleared up, a ligation of the long saphenous vein and its branches at the saphenofemoral junction is

done. The short saphenous vein, if it is involved, should also be ligated at its termination in the popliteal vein.

When it is evident the skin graft has taken, usually in about two weeks, an elastic adhesive (Elastoplast) bandage is applied from the toes to the knee. It is placed directly over the ulcer area. The patient is allowed up and discharged home in a few days. The bandage is renewed after three weeks. At the end of six weeks, the skin is usually in a satisfactory condition for the ligation of the communicating veins.

Anesthesia.—The anesthetic of choice is spinal anesthesia. Our technic has been to use 150 mg. of novocain crystals dissolved in 3 cc. of spinal fluid. This is injected through the third or fourth lumbar space. It should be done with the patient lying on the side which is to be operated upon.

The Position of the Patient.—This is very important, as the correct position simplifies the operation by giving proper exposure. If the medial group of veins is to be ligated, the patient should be placed in the Sims' position lying on the side with the affected extremity. This gives an excellent exposure of the medial side of the lower leg. If the anterolateral group is to be operated upon, the patient lies on his back and for the posterolateral group he is placed face downward with the feet everted.

The incisions for all three groups should be made in a straight line and parallel to the long axis of the leg (insets Figs. 2, 3 and 4). In each instance it is carried through the deep fascia down to the muscles and tendons. Many superficial varicosities are severed but these demand no special attention other than ligation of them. As soon as the incision has been completed in its entire length the wound is protected from contamination by the use of towels attached to the skin. As it is very important to avoid trauma to the skin edges, the towels are held in place by a continuous silk suture as shown in Fig. 6.

Ligation of the Medial Group of Communicating Veins.—The incision for operation on the medial group of veins is made on the inner side of the lower leg. It should extend from the level of the lower border of the medial malleolus, midway between it and the internal tubercle of the os calcis, to just below the upper end of the tibia and about a thumb's breadth posterior to the medial edge of that bone (inset Fig. 2). It is important to make the incision straight even though it must go through old scarred tissue or a healed ulceration. In some cases it is permissible to curve the incision slightly to skirt the edge of a healed ulcer, but it should not be carried too far posteriorly as this may result in sloughing of the anterior skin edge.

After the division of the deep fascia the gastrocnemius and soleus muscles are visible in the upper and middle thirds of the incision. In the lower third the Achilles tendon and the lamina profunda of the deep fascia covering the posterior tibial nerve, artery and vein, also the tendons of the tibialis posticus and flexor digitorum longus muscles are brought into view (Fig. 6).

When the skin has been covered with towels, the dissection is carried forward by elevation of the anterior edge of the wound. This is done by

traction on hemostats applied to the cut edge of the deep fascia (Fig. 6). Small rake retractors may also be used but the skin should never be picked up with forceps, as this may produce sufficient trauma to cause a slough.

The dissection is carried forward beneath the deep fascia to the medial edge of the tibia. This is done with great facility as the operative field is bloodless except for the communicating veins and arteries. Beginning in the upper third of the leg these vessels are isolated, divided and tied beneath the deep fascia. The arteries accompanying the veins are so small it is not necessary to preserve them. The uppermost communicating veins emerge through some of the fibers of the soleus muscle. After dividing and tying these proximal ones the dissection is carried toward the foot. The veins at the junction of the middle and lower thirds are the ones most frequently found incompetent. In the lower one-half of the leg it is necessary to divide longitudinally the lamina profunda of the deep fascia (Fig. 6). By doing this the deep vessels and nerves and the tendons of the posterior tibial and flexor digitorum muscles are brought into view. Frequently the communicating veins can be readily traced to their origin from the posterior tibial veins.

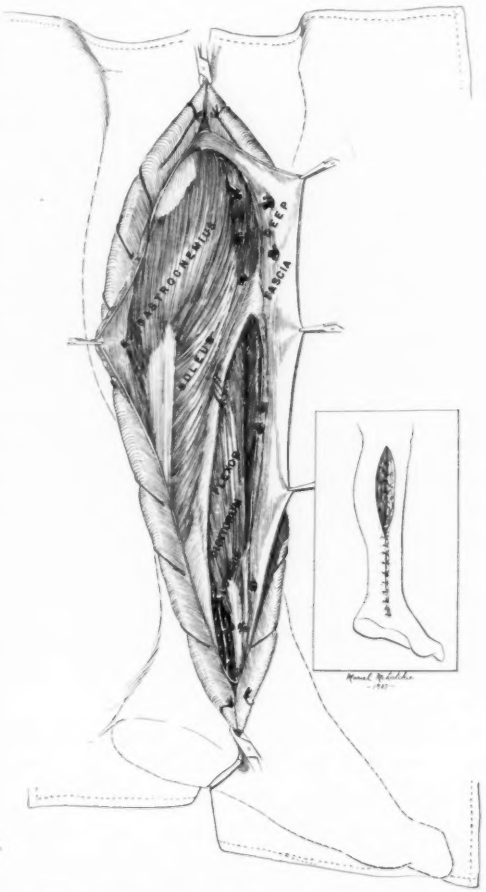

FIG. 6.—An operative sketch to show the method of ligation of the medial group of communicating veins. Note the use of towels sewed to the skin edges to protect the wound from contamination by the skin, and the retraction of the skin and deep fascia by means of hemostats attached to the latter. Posteriorly the fascia has been elevated sufficiently to permit ligation of the popliteal communicating vein. The lamina profunda or deep layer of the deep fascia has been divided. This brings into view the posterior tibial vessels, nerve and flexor digitorum longus muscle. This step is necessary in order to reach the communicating veins in the lower one-half of the leg. This muscle has been retracted bringing into view the inner side of the tibia and the medial subdivision of the anterior tibial communicating veins. The inset shows the method of closure of the wound with interrupted stitches.

The dissection behind the medial malleolus is the most difficult because the communicating veins are very short and the tissues even though normal are very taut and rigid which permits very little retraction. Great care must be exercised not to injure the posterior tibial vessels and nerve because at this level they lie immediately beneath the fascia. The posterior tibial veins are usually

found relatively large and tortuous and should not be mistaken for varicose communicating veins.

After ligation of all the communicating vessels in this area the inner edge of the tibia is next visualized from just above the medial malleolus to almost the junction of the upper and middle thirds of the leg. This step is necessary in order to visualize the medial subdivision of the communicating veins from the anterior tibial vessels (Fig. 6). In the proximal part of the operative field it may be necessary to free the soleus muscle from the medial edge of the tibia so that the upper veins of this group may be seen.

Ligation of these veins, if dilated, may be difficult because they are so adherent to the periosteum of the tibia. The most satisfactory procedure is to incise the periosteum on both sides of the dilated vein. A ligature can then be readily passed around the vein by elevating it with the periosteum. If these vessels are found to be normal in size they are not ligated.

The posterior edge of the wound should also be elevated as there may be communicating veins in the lower portion of it (Fig. 2). Opposite the middle of the lower leg the fascia is elevated sufficiently far enough to ligate the communicating vein from the popliteal vein which lies between the two heads of the gastrocnemius muscle (Fig. 6).

After the ligation of the communicating veins is complete, the wound is thoroughly washed out with normal saline solution. Then the deep fascia is sutured with interrupted stitches of No. 5 silk (inset Fig. 6). This is an important step because these sutures prevent tension on the skin stitches which, if present, would interfere with healing. Interrupted sutures of fine silk are also used for the skin. Silver foil is placed directly over the closed wound and a large gauze dressing applied.

Ligation of the Anterior Group of Communicating Veins.—The incision for the exposure of these veins is made in a straight line midway between the tibia and fibula from the level of the upper end of the latter bone to that of the lateral malleolus (inset Fig. 3). After dividing the deep fascia the tibialis anticus muscle is seen in the incision. Lateral to it lie the extensor digitorum longus and the peroneus longus muscles.

The veins of the central subdivision of the anterior tibial group are exposed by retracting the tibialis anticus muscle laterally. This exposes the lateral surface of the tibia in all except the upper one-sixth of the bone. The communicating veins are readily visualized on the periosteum (Fig. 3). If they are dilated, they are ligated in a manner similar to that described above for the ones on the medial side of the tibia. If they are normal, as they are in most cases, they need not be disturbed.

The veins of the lateral subdivision are found by dividing the anterior (peroneal) intermuscular septum which separates the peroneal muscles from the extensor digitorum longus muscle (Fig. 5). The dissection is carried distally to the lower edge of the lateral malleolus. All the communicating veins are ligated and divided. The wound is then cleansed with normal saline and closed with interrupted silk sutures in the fascia and the skin.

Ligation of the Lateral Group of Communicating Veins.—The incision for the exposure of this group of veins is made in a straight line posterior to the lateral malleolus midway between it and the lateral tubercle of the os calcis. It should extend vertically upward on the posterolateral surface of the lower leg from the lower border of the malleolus to the upper third of the lower leg (inset Fig. 4).

After dividing the deep fascia, the Achilles tendon and the lower fibers of the soleus muscle will be recognized in the posterior and distal portion of the wound. The peroneus brevis and longus muscles and tendons lie anteriorly separated from the gastrocnemius and soleus muscles by the posterior (peroneal) intermuscular septum along which the communicating veins will be found. The short saphenous vein is usually encountered and divided in the lower end of the incision. The sural nerve accompanies this vein and care should be taken not to injure the nerve. The dissection may be carried posterior in the midportion of the leg in order to ligate the popliteal communicating vein. The operative wound, as in the other incisions, is closed with interrupted silk in the fascia and the skin.

Postoperative Treatment.—After the dressing has been applied, the foot and ankle are immobilized by applying a posterior plaster splint from the toes to the knee to aid primary wound healing. The foot is placed in dorsiflexion and as nearly as possible at a 90° angle with the lower leg.

The patient is kept in bed for a period of 10 to 14 days or longer depending on the condition of the wound. The dressing is not changed until the tenth day, unless there are signs of wound infection. Every alternate stitch is removed at this time and the remainder of them are taken out on the twelfth day.

A certain amount of edema of the lower legs may appear after the patient becomes ambulatory. To reduce this to a minimum the following measures are taken. First, before the patient is permitted to be up and about he carries out postural leg exercises for three to four days, to reestablish normal circulatory tone and to prevent the development of peripheral edema. These exercises are a modification of those described by Buerger[7] and Allen[8] in that the period of elevation is longer than the period of dependency. They are done by elevating the legs to a 30° or 40° angle with the horizontal for a period of three minutes. Then the lower legs are hung over the side of the bed for two minutes. This is followed by a five minute rest with the legs in the horizontal position. The exercises are done in half-hour or hourly periods for a total of three or four hours a day. Second, when the patient is allowed out of bed, the legs are bound firmly from the instep to the knee with an elastic adhesive (Elastoplast) bandage. Third, he is instructed when sitting to elevate his legs on another chair. Walking is begun for very short periods and increased gradually. Most patients wear supporting bandages for one month to six weeks following discharge from the hospital.

Discussion.—The communicating veins of the lower extremity have been

described anatomically and divided into three main surgical groups: The medial, the anterior and the lateral. The purpose of this classification is to simplify the surgical approach to them in varicosed conditions of the lower leg.

Ligation of the perforating veins has been advocated for many years; Rémy,[5] in 1901, Homans,[9, 10] in 1916 and 1917, and Trout,[11] in 1929, have stressed the importance of this fact. It should also be noted that a procedure termed the "flap" operation for the ligation of the perforating veins has been carried out at the Massachusetts General Hospital for a number of years. The operation consisted in making a curved incision on the lower leg where the incompetent perforating veins were found. This permitted the elevation of a flap of skin and fascia so that the veins could be ligated beneath it. Neither the technic nor the results of this operation have been described in the literature. This is probably because the use of a curved incision with the actual formation of a flap of skin and fascia frequently resulted in sloughing of the skin edge. The incision as a result often required weeks, months, or longer to heal so that the operation fell into disrepute.

Since it is imperative to interrupt the communicating veins if they are incompetent, it was felt expedient to develop an operative procedure that would eliminate the faults of the old operation. The operative technic is given in detail. Through three properly placed incisions, it is possible to ligate all of the communicating veins in the lower leg. If the precautions described are taken, these wounds heal by primary intention.

All the communicating veins are rarely found to be incompetent. However, it is not unusual to find that two groups in the same leg may be affected. The medial group is the one most commonly at fault. In about 80 to 90 per cent of the cases with incompetent communicating veins, this group is involved. In 15 per cent the lateral group and in 5 per cent the anterior group are incompetent. The increased frequency of incompetence in the medial group probably is because the posterior tibial veins, from which the medial group arises, lie relatively superficial in the distal half of the lower leg. Thus the communicating veins pass outward chiefly through tendinous structures that give them little support. On the other hand, the anterior tibial and peroneal veins lie more deeply among the muscles of the leg. The communicating veins from these two systems pass outward between muscular structures and accordingly receive greater support than those of the medial group. The clinical examination will usually suffice to indicate which group of veins requires ligation.* High ligation of the long saphenous vein and short one if it is incompetent should be performed prior to the ligation of the communicating veins.

REFERENCES

[1] Braune, Wilhelm: Das Venensystem des menschlichen Körpers. (2) Lfg. Die Venen des Fusses und Unterschenkels, auf der topographischen Abtheilung des anatomischen Instituts zu Leipzig bearbeitet von Dr. Paul Müller. Leipz., Veit & Comp., 1889.

* Another paper is to be published on the indications for the operation and case reports.

[3] Faxon, H. H.: The Treatment of Varicosites; Preliminary High Ligation of the Internal Saphenous Vein with the Injection of Sclerosing Solutions. Arch. Surg., **29**, 794, November, 1934.

[4] Klotz, K.: Untersuchungen über die Vena saphena magna beim Menschen, besonders rücksichtlich ihrer Klappen-verhältnisse. Arch. f. Anat. u. Physiol., p. 159, 1887.

[5] von Loder, J. C.: Anatomische Tafeln. Text (2 Vol.) Weimar, 1803 (Tab. 127).

[6] Rémy, C.: Traité des varices des membres inférieurs et de leur traitement chirurgical. Paris, Vigot fréres, 1901.

[7] Meisen, V.: Varicose Veins and Hemorrhoids. Oxford University Press, London, 1932.

[8] Buerger, Leo: Circulatory Disturbances of the Extremities. W. B. Saunders Co., Philadelphia, 1924.

[9] Allen, A. W.: Recent Advances in the Treatment of Circulatory Disturbances of the Extremities. ANNALS OF SURGERY, **92**, 931, November, 1930.

[10] Homans, J.: Operative Treatment of Varicose Veins and Ulcers. Surg., Gynec., and Obstet., **22**, 143, February, 1916.

[11] Homans, J.: The Etiology and Treatment of Varicose Ulcers of the Leg. Surg., Gynec., and Obstet., **24**, 300, March, 1917.

[12] Trout, H. H.: Ulcers Due to Varicose Veins and Lymphatic Blockage. Arch. Surg., **18**, 2281, June, 1929.

INJURIES ABOUT THE SHOULDER JOINT IN CHILDREN, EXCLUSIVE OF FRACTURES OF THE CLAVICLE

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SIXTY-ONE children, under 12 years of age, with injuries about the shoulder joint, exclusive of fractures of the clavicle, were admitted to the Children's Surgical Service of Bellevue Hospital during the past ten years. Fifty-five of them had fractures of the upper end of the humerus, four had fractures of the scapula, one had a subluxation of the head of the humerus, and one had an acromioclavicular separation.

There were no instances of separation of the upper humeral epiphysis, or of apparent injury to this epiphysis, and no cases were diagnosed as epiphyseal strain. There were no cases of capsular tear or injury to the subacromial bursa, and no injuries to the brachial plexus were noted. There was no mortality.

All cases of fracture of the upper end of the humerus, in this series, were over 20 months of age. It occurred more frequently in children over six, and twice as often in boys as in girls. Its incidence was one-seventh that of fracture of the lower end of the humerus, one-fourteenth that of fracture of the forearm and one-half that of fracture of the clavicle. Falls were the cause of the fractures in 45 cases, and automobile accidents in nine. One pathologic fracture followed the throwing of a ball.

Codman[1] has given a clear explanation of why falls produce fractures of the upper end of the humerus: When the arm is elevated above 90 degrees in the sagittal plane, this elevation must be accompanied by internal rotation; when it is performed in the coronal plane it must be done in external rotation. When an individual falls the arms is usually thrown upward and forward in the sagittal plane, in order to fend the body off the ground. If internal rotation is prevented after the horizontal plane is reached, then some bony or ligamentous structure must give (Fig. 1). If the arm is in the coronal plane when the fall occurs and external rotation is prevented, the same result follows (Fig. 2). In children, it is the upper end of the humerus that breaks. This is because the tip of the acromium and the head of the humerus are cartilaginous, and as the head ascends higher beneath the acromium in children, the weakest point is just above the insertion of the adductor group of muscles. Since in children the insertions of the muscles of the roof of the shoulder joint are fleshy to near their attachments,[2] they do not rupture.

The importance of this muscular coordination in falls is borne out by the difference in the number of fractures occurring in the right and left arms.

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The left humerus was fractured in 34 cases compared to 21 fractures of the right humerus. This discrepancy is more marked as the children grow older and usually develop finer muscular coordination in the right arm. In this series, during the first six years of life, there were seven fractures of the left and six of the right humerus. Between the ages of seven and 11, there were 27 fractures of the left and 15 of the right humerus.

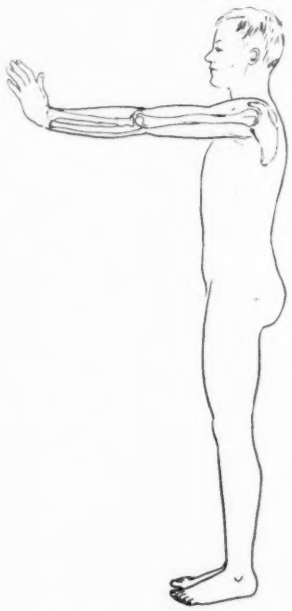

FIG. 1.—Illustrates that the humerus is not in internal rotation and, as further elevation occurs, some bony or ligamentous structure must give.

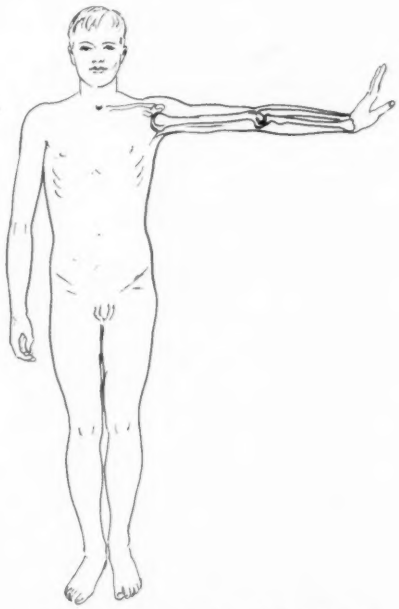

FIG. 2.—Illustrates that the humerus is not in external rotation, therefore, further elevation of the arm cannot occur without injury to the humerus or the ligaments.

The majority of fractures in this series were at a lower level in the humerus than are usually found in fractures of the same region in adults. There were 34 fractures in this location, which is really the upper one-fourth of the shaft of the humerus. This agrees with the findings of Howard and Eloesser,[3] who believed it was due to two factors: The relatively lower insertion of the adductor group of muscles (the pectoralis major, latissimus dorsi and teres major) in children, and to the low level of transition between cancellous and dense cortical bone that exists in the shaft of the growing humerus. Of the 34 fractures, 18 were transverse and without displacement. There was slight medial displacement of the lower fragment in eight cases and marked medial displacement of the lower fragment in five cases. There were two instances of slight lateral displacement of the lower fragment, the so-called buckling type of fracture, and one of marked lateral displacement of this fragment. Marked displacements of the fragments occurred only in children over five and were the result of severe trauma.

Eighteen of the fractures were similar in location to those commonly

found in the surgical neck of the humerus in adults. With one exception, these fractures occurred in children of seven years of age and over. Of the 18, 15 were adduction fractures and three were the result of abduction. This is in agreement with the report of Perkins and Jones[4] also, who found that adduction fractures were more common in children. Their explanation of why these displacements occur is as follows: "When the neck of the humerus is fractured in a fall on the outstretched hand, the type of fracture and direction of displacement depend on whether, at the moment of impact, the limb is carried inwards into the adducted position or outwards in the abducted position. From adduction force an adduction fracture results, with outward angulation and impaction of the fragments on the inner side of the neck."

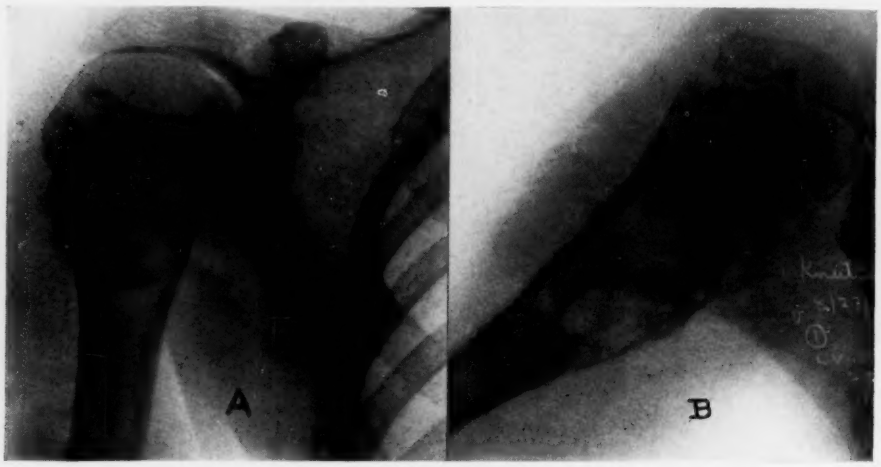

FIG. 3A and B.—Illustrating pathologic fractures through bone cysts.

There were three pathologic fractures in this series. Two were fractures through bone cysts of the upper end of the humerus (Fig. 3). They occurred in children age seven and nine respectively, and both were caused by slight trauma. In one case the fracture was caused by a fall and in the other it followed the throwing of a ball. They were both transverse fractures through the cysts with no displacement of the fragments. The fracture did not induce healing of the cyst in either case. The third pathologic fracture occurred in a boy, age ten, who had a partial paralysis of the left arm and imperfect growth of the humerus following poliomyelitis. The fracture was caused by the boy's rolling over on the arm while in bed. It was a spiral fracture of the upper one-fourth of the shaft of the bone with slight medial displacement of the lower fragment. The fracture was firmly healed at the end of four weeks, and the function of the arm, within two months, was the same as before the injury.

In only four children were there other injuries of any consequence accompanying the fracture of the humerus. Two of them were struck by automobiles. In one of these the lung was ruptured and in the other there was a

fracture of the outer one-third of the clavicle. One boy, age five, fell four flights and fractured both ends of the same humerus and the shaft of the femur. There was slight displacement of the fragments in the fracture of the upper end of the humerus and none in the fracture of the lower end. The fourth patient was a boy, age ten, who fell on his outstretched hand, while running, and fractured both ends of the same humerus. There was little displacement of the fragments in either fracture. It is interesting to note that in these four cases all of the injuries were on the same side of the body.

Treatment.—In those cases where there was any appreciable displacement of the fragments, an attempt was made to improve the position by either reduction under anesthesia or by traction. In our experience anatomic restoration of the fragments by manipulation under anesthesia was a disappointing procedure. Eight patients were treated in this manner and in only two was a good reduction obtained. In both of these, there was a transverse fracture of the upper one-fourth of the shaft of the humerus with medial displacement of the lower fragment. In one other case the position was considerably improved. There was no improvement in the alignment in five cases. Of these five cases, three were later placed in traction which resulted in fair anatomic restoration, but in the other two cases there was little improvement in the position even by traction. However, the anatomic and functional results in all eight cases were very good six months after the injuries, due to the processes of absorption and growth of the bones.

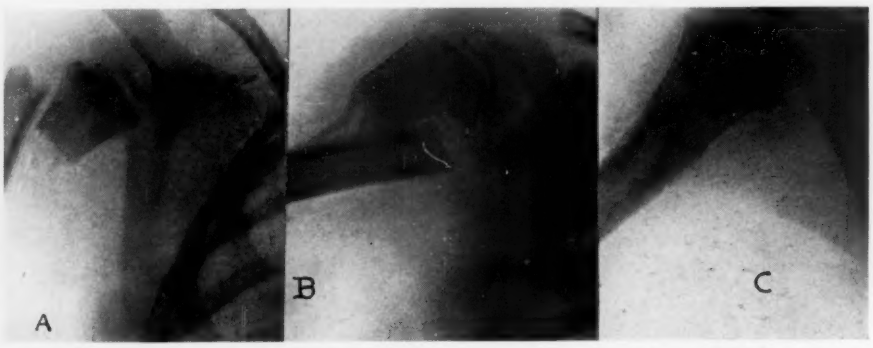

FIG. 4.—(A) An uncorrected position following a fracture of the proximal end of the humerus. (B) One month later showing beginning realignment of the shaft. (C) Seven and one-half months after fracture showing almost complete anatomic restoration.

Thirteen cases were treated primarily by means of skin traction. The position of the fragments in most of these was improved but the degree of improvement depended upon the type of fracture. The position of the fragments in transverse fractures, lower in the shaft, was easier to improve by traction than the position in the adduction and abduction types. In two patients who had transverse fractures with marked displacement of the fragments, traction only slightly improved the position and the fragments were allowed to heal in poor anatomic apposition (Figs. 4 and 5). Both patients obtained good functional results within two months and good anatomic results

within eight. The position of the fragments in one patient with an adduction type of fracture was unimproved by traction and was allowed to heal in poor position (Fig. 6). A roentgenogram three years later, however, showed no evidence of the former fracture. Nine of the ten other cases, treated by traction, were seen at intervals after leaving the hospital and the functional and anatomic results were excellent in all.

The arms of 26 patients were immobilized by means of anterior and

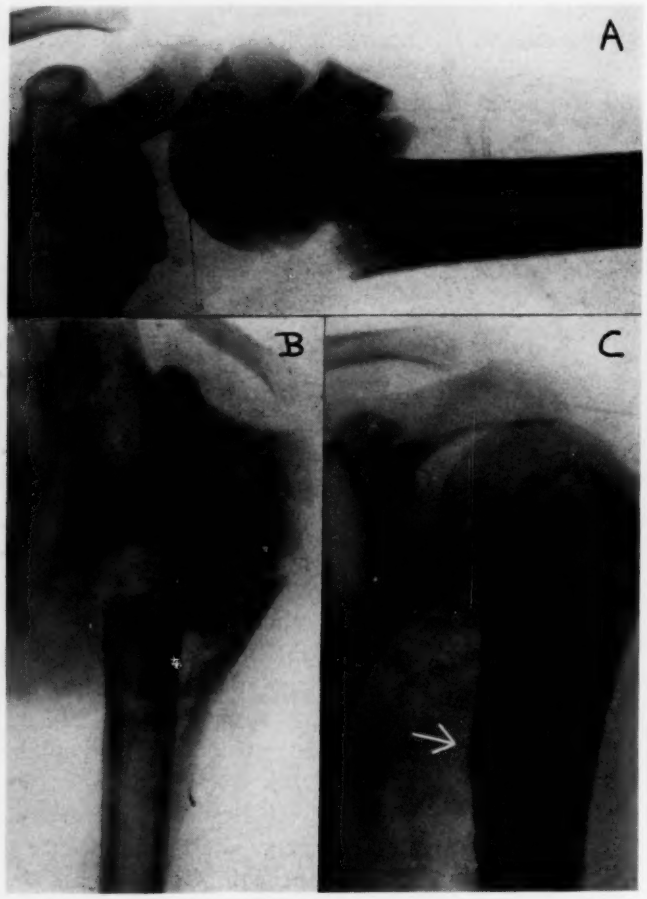

FIG. 5.—(A) An uncorrected position following a fracture of the proximal end of the humerus. (B) One month later showing beginning realignment of the shaft. (C) Four months after fracture showing almost complete anatomic restoration.

posterior molded plaster splints, no attempt being made to improve the position of the fragments. In only one case, however, was there much displacement. Twenty-one of these patients were seen in the follow-up clinic and had excellent anatomic and functional results.

Eight patients were treated with the arm in either a modified Velpeau bandage or a sling. There was no displacement of the fragments. Good

anatomic position was not jeopardized by this form of partial immobilization. We have found complete anatomic restoration of the fragments, in fractures of the upper end of the humerus in children, to be desirable, but not essential. In this series, even in those cases with poor alignment of the fragments, good functional results were obtained within two months. Complete anatomic readjustment occurred within eight months. Rotatory deformities produced no functional disturbance. Operative interference was not considered necessary in any of the cases and, indeed, judged from the end-results, it would not have been justified.

Dislocation of the Head of the Humerus.—Dislocation of the head of the humerus is a rare occurrence in children. One instance, however, included in this series, was a boy, age nine, who had fallen from a swing. When admitted to the hospital there was considerable swelling of the shoulder, and a gross deformity was present. He complained of severe pain on any motion

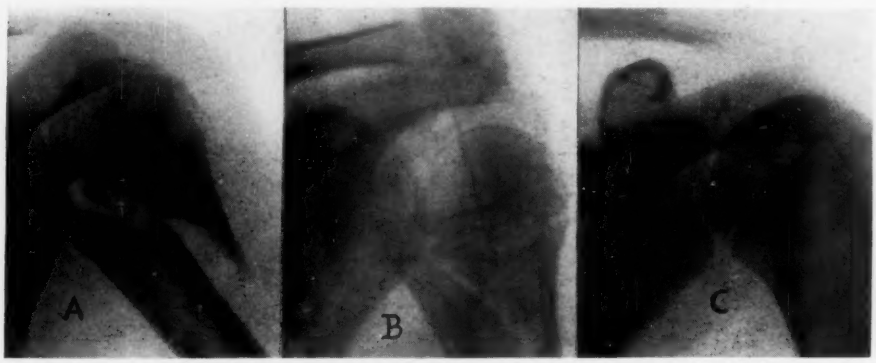

FIG. 6.—(A) An uncorrected position following an adduction fracture of the proximal end of the humerus. (B) Appearance three weeks later after the application of traction. (C) Appearance three years after fracture showing no evidence of the original deformity.

of the arm. Roentgenologic examination showed partial downward subluxation of the head of the humerus (Fig. 7). The subluxation was easily reduced under anesthesia, and the boy had normal function of the shoulder joint within 16 days.

Acromioclavicular Separation.—This also occurred but once in this series, in a boy, age eight, who had a partial paralysis of the same arm, following poliomyelitis. He was struck by a bicycle and fell directly on his shoulder. He was treated by means of an adhesive plaster bandage, which immobilized the arm and shoulder. He was discharged from the hospital six days after the injury and was free from pain at that time. Unfortunately he did not return to the outpatient clinic nor could he be located for subsequent observation.

Fracture of the Scapula.—There were four cases of fracture of the scapula. In three of them the fracture was of the body of the scapula and in one it was through the acromium process.

Two fractures of the body of the scapula occurred in children, age six and

seven, respectively, both of whom were struck by moving vehicles. There was no appreciable displacement of the fragments in either case. In one case, because of a serious intracranial injury, the fracture was not diagnosed for several days, and no attempt was made to immobilize the scapula. In the other, the arm and shoulder were immobilized by means of a Velpeau dressing. The functional result in both patients was excellent within four weeks.

The other fracture of the body of the scapula occurred in a boy, age 11,

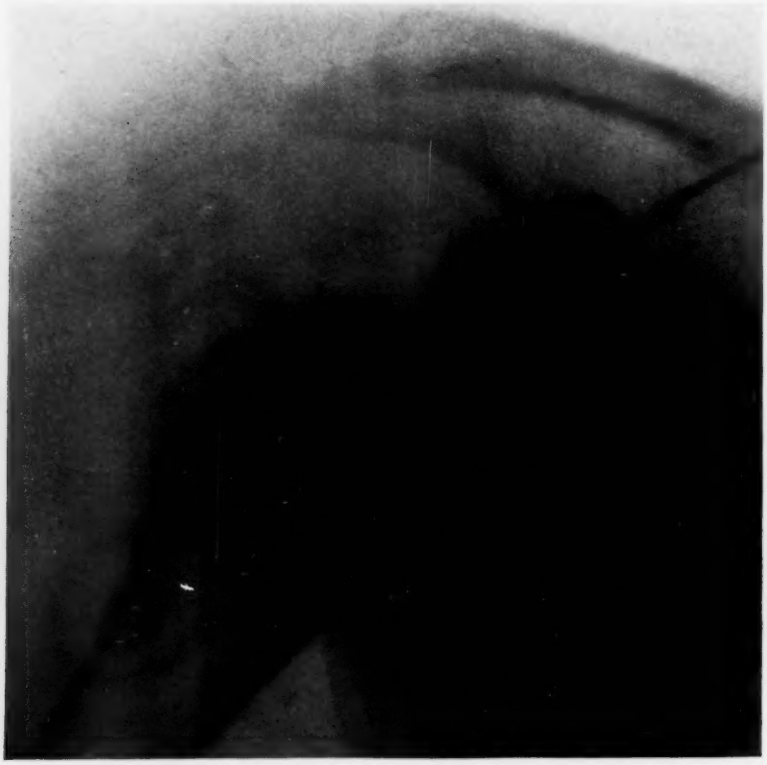

FIG. 7.—Showing a partial subluxation of the head of the humerus.

who was struck by a truck. Besides the fracture of the left scapula there was also a fracture through the middle third of the left clavicle with complete dislocation of the outer end of the clavicle and displacement of the outer half of the clavicle in a vertical direction. There was slight displacement of the fragments of the scapula. The arm was placed in abduction and traction was applied for about 30 days. A perfect functional result was obtained in this case within six weeks. There was anatomic restoration by means of absorption of the displaced outer half of the clavicle, and reformation of a new clavicle. This case has been reported by Beekman.[5]

The fracture of the acromium process occurred in a boy, age eight, who had fallen from a bicycle, striking his left shoulder. He had fractured the lower end of his left humerus two years previously and following this the left

forearm and hand were partially paralyzed. There was no displacement of the fragments in the acromium. The arm and shoulder were immobilized by means of a Velpeau dressing and the boy was discharged from the hospital six days after injury. He failed to return for subsequent observation.

SUMMARY

(1) The most common injury about the shoulder joint, excluding fracture of the clavicle, in children admitted to the Children's Surgical Service of Bellevue Hospital, was fracture of the upper end of the humerus.

(2) Fracture of the upper end of the humerus occurred three times as often in children over six years of age as in children under that age.

(3) The majority of fractures of the upper end of the humerus were caused by falls.

(4) The fractures occurred more often in the left than in the right humerus.

(5) There were only three pathologic fractures of the upper end of the humerus in this series.

(6) Most of these fractures of the humerus were unaccompanied by associated injuries.

(7) Good anatomic restoration of the fragments, while desirable, is not essential, as nature remolds the bone.

(8) There was but one case of dislocation of the head of the humerus.

(9) There were three cases of fracture of the body of the scapula and these were caused by severe trauma.

(10) Acromioclavicular separation and fracture of the acromium process occurred only in children with previously weakened arms on the same side as the injury.

REFERENCES

[1] Codman, E. A.: The Shoulder. Boston, 1934.

[2] Skinner, H. A.: Anatomical Considerations Relative to Rupture of the Supraspinatus Tendon. J. Bone and Joint Surg., **19**, 137, January, 1937.

[3] Howard, N. J., and Eloesser, L.: Treatment of Fractures of the Upper End of the Humerus. An Experimental and Clinical Study. J. Bone and Joint Surg., **16**, 1, January, 1934.

[4] Perkins, G., and Jones, R. W.: Fractures of the Humerus in the Region of the Shoulder Joint. Proc. Roy. Soc. Med., **29**, 1055, July, 1936.

[5] Beekman, F.: Fracture-Dislocation of the Clavicle. ANNALS OF SURGERY, **105**, 474, March, 1937.

STENOSING TENDOVAGINITIS AT THE RADIAL STYLOID PROCESS*

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STENOSING tendovaginitis at the radial styloid, or DeQuervain's disease, as it has been known, is, apparently, a disease which occurs not infrequently, but is not universally recognized, although first described in 1895. The name stenosing fibrous tendovaginitis is attributed to Kocher. This report is prompted by the fact that the writer had never operated upon such a case until 1937, and then encountered two instances within six months. A review of the literature disclosed that relatively few articles have been written on the subject, and that a surprisingly small number of cases have been reported. DeQuervain describes it as follows: "It is a condition affecting the tendon sheaths of the abductor pollicis longus, and the extensor pollicis brevis. It has definite symptoms and signs. The condition may affect other extensor tendons at the wrist."

Anatomic Relationship.—Patterson[7] gives a clear picture of the normal anatomy, when he states that: "The tendons of the abductor longus pollicis, and the extensor brevis pollicis, pass through a groove in the outer aspect of the styloid process of the radius, and are contained in a separate compartment of the annular ligaments. They are surrounded by a tendon sheath that extends about one inch above, and below, the carpal ligament. This sheath is filled with synovial fluid to facilitate the pulley-like action of the tendons."

Etiology.—The etiologic factor is supposed to be chronic injury, and apparently this is true in most cases, as it usually occurs among people who have to use their hands in occupations requiring constant repetition of certain motions, but a few cases are reported as starting with an acute onset. Case 1 definitely illustrates the possibility of the condition being caused by an acute injury. Finkelstein,[4] in 1930, stated that he believed that the onset was due to chronic trauma in most cases, but he listed six cases as being due to an acute trauma. Among the causative factors were piano playing, typewriting, use of the adding machine and excessive writing. Quoting Eichhoff, he gives one of the best descriptions of the cause, and development, of tendovaginitis as follows: "Work requiring a constantly repeating motion at the wrist, especially in ulnar abduction, with the thumb fixed on some object. With each motion in this position, the tendons of the extensor brevis, and abductor longus muscles, become taut over the styloid process of the radius, and press on the tendon sheath, which is unable to avoid pressure, because it lies close to the bone. As a second factor, during the ulnar abduction of the

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hand, with a fixed thumb, stretching of the entire tendon sheath is produced. The extension of the tendons of the two muscles is strongest when the thumb is in opposition to the hand in middle posture. If the hand, with the thumb, is now abducted in the ulnar direction, then both tendons, and with them the tendon sheath, must be over-stretched. A simple experiment will verify this assumption. If one places the thumb within the hand, and holds it tightly with the fingers, and then bends the hand severely, in ulnar abduction, an intense pain is experienced on the styloid process of the radius, exactly at the place where the tendon sheath takes its course. The pain disappears the moment the thumb is extended, even if the ulnar abduction is maintained. In cases of forced abduction of the hand, without simultaneous involvement of the thumb, one does not succeed in evoking this pain. Thus, repeated over-stretching of the tendon sheath results in injury to the gliding mechanism."

Pathology.—The pathology consists of a fibrosis of the common sheath as it lies in the groove at the lower end of the lateral portion of the dorsal carpal ligament. The explanation offered is that in this superficial situation, the tendons are exposed to injury, and increased friction. The friction causes edema, which further increases friction, and this ultimately causes the tendon sheath to thicken, and become fibrosed. Finkelstein states that the sheath has been known to thicken four times the normal, and to cut like cartilage. He reminds us that the normal thickness of the tendon sheath is one-thirty-second of an inch. Finkelstein found the tendon beyond the constriction to be bulbous. In the case herewith reported the bulbous swelling of the tendon was proximal to the constriction. The groove in the styloid has been known to show granulation tissue, with adhesions, and even adhesions between the tendons themselves. In his discussion of pathology, Finkelstein states: "The tendon sheath is considerably thickened, and that it constricts the underlying tendon, interfering with their normal gliding mechanism. Keppler believes the process to be chronic inflammation caused by protracted irritation of an aseptic nature. Troell believes that the pathologic process may occur in the tendon, and refers to two cases, one of fusiform swelling, consisting of chronic granulation tissue of the abductor pollicis tendon, and another case in which the tendon was surrounded by a loose tissue, rich in blood vessels, in the ligament compartment. Vischer concludes that in cases of stenosing tendovaginitis, the affection always begins with inflammation, which is followed by fibrous changes. Eichhoff states that, macroscopically, a thickening of the tendon sheath is always found. In general, the tendons themselves show no pathologic transformations. They may be compressed, however, by the stenosis in such a manner that they become separated into fibers." Finkelstein reports that, contrary to DeQuervain, he has found similar lesions in other tendon sheaths, and he was able to produce this lesion by animal experimentation.

Frequency.—Finkelstein,[4] in 1930, cited case reports of 28 patients. He, too, called attention to the difficulty in making a correct diagnosis of the condition. He records a case by Welti, in 1896, in which the entire fascia of the tendon sheath required excision. Several cases were reported by Marion

in 1903; Poulsen in 1911, two cases; DeQuervain in 1912, eight more cases requiring operation; Hauch, in 1923, described cases of tendovaginitis, and snapping finger; Stern,[2] of New York, reported cases in March of 1927 from Finkelstein's clinic; Schneider,[3] in 1928, also reported some cases. Bilateral instances have been reported by Keppler, who had two; Winterstein reported four such instances and Finkelstein has reported one bilateral case. Schneider found cases lasting one year, and reported cures in 60 per cent of them by conservative means. Brown,[6] in 1935, stated: "It is a condition strangely neglected by British writers." Burns,[9] in 1936, stated that only one case had been recorded in England up to that date. Patterson,[7] in 1936, stated that he had found only three papers by American authors. Counting all case reports found in foreign literature, and those reported by Finkelstein, about 250 are on record. Dr. Paul C. Swett, in discussing Patterson's paper, stated that he believed the condition to be much more frequent than generally recognized, and believed that it occurred more often in women, because they attempt to do things with their hands that they are not strong enough to do, and to which they are not accustomed. He reports many cases among doctors' wives. Doctor Colp reported an instance of bilateral tendovaginitis which occurred in an anesthetist, who had contracted it by the simple act of holding a can of ether in his hand, with his thumb held in a fixed position. While the affected wrist was being treated, he performed the same act, with the same fixed position, with the opposite hand, and developed a similar condition in that wrist also.

Characteristic Findings.—Various writers have reported the cases to be more frequent in women than men. It is usually present in people who do hard work with their hands, so they present a history of acute or chronic injury to the region of the wrist. The pain is usually directly over the styloid process of the radius, and is continuous, accentuated by motion, and radiates up the arm. It may even interfere with sleep. At first the "snuffbox" of the thumb is distinctly shown, but gradually disappears, and finally the thumb gives an appearance as though the extensor tendons had lost their continuity, and the patient appears unable to extend the thumb at all, and there is a suggestion of atrophy of disuse. In some cases there is a bulbous swelling in the region of the styloid. Passive motion causes pain, and active motion is absent, and the patient tends not to use the hand. Point pressure over the styloid invariably causes the patient to wince, and withdraw the hand. Burns and Ellis[9] stated that the diagnosis is certain if, on grasping the hand and quickly adducting the thumb, a sharp pain occurs referred to the styloid process of the radius.

Symptoms.—These at first are so mild that the condition is recognized with difficulty, and they become serious so insidiously that the patient is incapacitated before the full significance of the situation is apparent. The characteristic history is that the patient has experienced either mild or severe injury to the wrist. This injury may be either constant motion at the wrist, such as is necessary in wringing clothes, or it may be an injury sustained from a fall, or, indeed, trauma of any degree. Pain persists at the wrist, and

the patient usually points in the region of the radial styloid. Any motion of the thumb is painful, and ultimately impossible, both from pain, and from mechanical disability. The pain may involve the thumb, the wrist, and finally the arm, to the point where the patient ultimately carries the arm in a sling. Women complain that they cannot arrange their hair, or hold any object in the hand. There may, or may not, be a swelling, which is confusing. Burns stated that, so far as he knew, stenosing tendovaginitis is the only cause of pain at the styloid of the radius, with disability in motion of the thumb. Zelle and Schnepp[8] use the name tendovaginitis, or "snapping thumb," as synoymous terms. Few of the other writers mention this as a cardinal symptom, and it is well not to be misled by the absence of the snap. Finkelstein's[4] description of the pathognomonic sign is as follows: "On grasping the patient's thumb, and quickly abducting the hand ulnarward, the pain over the styloid tip is excruciating."

Differential Diagnosis.—Finkelstein lists the following diseases as those necessary to exclude, before the diagnosis is certain: Tuberculous tendovaginitis, tuberculous osteitis, tendovaginitis crepitans, periostitis, neuritis, arthritis of either gouty, rheumatic, gonorrheal or syphilitic origin. All authors agree that stenosing tendovaginitis is neither luetic nor tuberculous. Burns and Ellis remind us that the condition may be confused with fracture of the scaphoid, because of tenderness in the anatomic snuffbox. They state that the presence of a bulbous swelling is the differential point in clinical diagnosis. Roentgenologic examination, of course, would help in case of injury to the scaphoid. Burns states that the more difficult diagnosis is from sprain of the external lateral ligament of the wrist. Patterson[7] reminds us that these cases are confused with those of sprain, arthritis, neuritis, osteitis, periostitis, and tenosynovitis.

Roentgenologic Findings.—Brown[6] is the only author who has reported any positive roentgenologic findings. His case showed periosteal irritation.

Treatment.—Palliative measures, as a rule, are not successful. In a few cases, a plaster encasement, holding the thumb in full abduction, and extension, has given relief. Spontaneous cure has occurred in a few instances. This, without operation, however, seems to require a long period, sometimes as long as one and one-half years. The ideal treatment is operation. This is true because of the speed with which the patient is relieved of the symptoms, and the short space of time required to restore the hand to use. The results are striking, and in some cases almost unbelievable in their suddenness. The procedure consists in the simple process of incising the tendon sheath longitudinally, to release the constriction. In some cases, a removal of a section of the bulbous portion of the sheath was necessary before the entire constriction was relieved. Zelle and Schnepp first incised the tendon sheath, and then made a longitudinal incision in the tendon sheath itself, at the bulbous portion. They then excised the center of the bulbous swelling in the tendon, and restored the tendon to normal size. Finkelstein favors conservative treatment in the acute stages, and quotes others as reporting cures by this

method. He advises immobilization by a plaster encasement, compression bandage or splint, baking, massage, diathermy, counterirritants in the form of vesicants, and finally, potassium iodide internally. He advises operation after four weeks of treatment.

Prognosis.—Finkelstein reports excellent operative results, but urges extensive removal of the tendon sheath in any doubtful case; otherwise, pain will persist at the styloid process, which occurred in two instances in his own series.

Case Report.—The patient, a female, applied for relief from pain at the radial styloid, following a fall, April 1, 1936, at which time she sustained an injury of the left hand. There was immediate pain, and disability. On inspection, the wrist was relatively normal in appearance, despite the history of acute trauma. The extensor tendons appeared to be normal, and the anatomic snuffbox was present, although there was limitation of flexion and extension. Palpation at the radial styloid caused pain, and the patient's tendency was to draw the hand away from the examining finger. Not only was active motion restricted, but passive motion caused pain. There was no bulbous swelling apparent at any time. Fracture of the scaphoid was suspected, but roentgenologic examination was negative. The patient was treated with immobilization and rest, without relief. The pain became worse, and the patient carried the arm in a sling. Shortly, the wrist was held so immobilized that the tendons were not visible, and loss of continuity was actually suspected. The anatomic snuffbox became obliterated, and the wrist took on the appearance of atrophy of disuse. The pain at the styloid remained constant, and any motion caused pain. The patient complained that she was frequently awakened from sleep by the pain, that she could not use the hand to comb her hair, could not hold her fork, or even light objects. Besides immobilization and sling treatment, the area was treated with external applications, heat and diathermy.

Operation.—A linear incision was made along the sheath, the center of it being over the styloid process. The sheath was found markedly thickened, but not bulbous. The tendon was swollen from pressure, and this swelling, contrary to that which is usually recorded, was proximal to the constriction. A portion of the diseased sheath was removed and submitted for pathologic examination. The wound was closed loosely.

Postoperative Course.—Within 24 hours the result was striking, as the patient could both flex and extend the thumb, which she had not been able to do for months. After 48 hours the anatomic snuffbox was distinctly visible, and within this short time, the patient had lost practically all of the preoperative discomfort. The pathologic report was granulation tissue with chronic inflammation.

REFERENCES

[1] Hoffman, P.: Translation American Orthopedic Association, **11**, 252, 1898.
[2] Stern, H. C.: Stenosing Tendovaginitis. Amer. Jour. Surg., **3**, 77, July, 1927.
[3] Schneider, C. C.: Stenosing Fibrous Tendovaginitis over Radial Styloid. Surg., Gynec. & Obstet., **46**, 846, June, 1928.
[4] Finkelstein, H.: Stenosing Tendovaginitis at the Radial Styloid Process. J. Bone and Joint Surg., **12**, 509, July, 1930.
[5] Compere, Edward L.: Bilateral Snapping Thumbs. Amer. Surg., **97**, 773, 1933.
[6] Brown, W. M.: Brit. Med. Jour., **2**, 538, September 1, 1935.
[7] Patterson, Daniel C.: DeQuervain's Disease, Stenosing Tendovaginitis at the Radial Styloid. New England Jour. Med., January 16, 1936.
[8] Zelle, Oscar L., and Schnepp, Kenneth H.: Snapping Thumb, Tendovaginitis Stenosans. Amer. Jour. Surg., August, 1936.
[9] Burns, B. H., and Ellis, V. H.: Stenosing Tendovaginitis at the Radial Styloid Process. Lancet, London, March 28, 1936.

THE BACTERIAL FLORA OF CLEAN SURGICAL WOUNDS

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INFECTION is known to occur in 5 per cent of all clean surgical wounds even though they are made with due regard to all the principles of aseptic surgical technic.[1 to 9, 12 to 19, 25] A great deal of time has been spent in the study of these wound infections, but as far as we know, Hunt[11] is the only worker who has made cultures of surgical wounds during the actual operation. He cultured 28 abdominal wounds after the peritoneum had been closed and in all but three instances obtained large numbers of bacteria, which, however, were not identified, but were considered to have fallen into the wounds from the air.

The paucity of information in the literature upon the bacteriology of surgical wounds and its importance in relation to the problem of wound infection made the authors feel that it would be of importance to carefully culture a series of wounds during the actual operation. It was decided to:

Procedures.—

(1) Take cultures of the skin after it has been prepared for operation.

(2) Expose blood agar plates to the air of the operating room during the course of the operation.

(3) Take cultures of a series of clean wounds during the actual operative procedure.

(4) Follow the healing of the wounds that had been cultured.

(5) Review the infections that had occurred in clean wounds on the Surgical Service of the New Haven Hospital during the last three years to determine the incidence of the various types of organisms and their relation to those found in the air, on the skin, and in the wounds at operation.

The period of the survey ran from October 12, 1936, to March 26, 1937. Thirty clean cases were cultured and with the exception of one thoracoplasty all of the wounds were in the abdominal wall. No case was studied if there was any possibility of contamination with feces, pus, urine or bile. Hysterectomies, following which an appendicectomy was performed, were included when the appendix showed no evidence of inflammation.

Each case was recorded as to name, date, type of operation, surgeon, time of wound exposure from the final draping of the operative field until the dressings were applied, and the approximate number of people in the operating room.

When a culture was taken of the skin, three swabs were passed from the instrument nurse to the surgeon who swabbed the skin and returned the

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swabs to the nurse. The nurse then passed them to one of the authors in such a manner that he could grasp the distal one-half inch of the stick. Neither the surgeon nor the nurse touched the swab or the stick within two inches of the swab. One swab was immediately streaked on a meat infusion agar plate and another placed in a sterile flask containing 100 cc. of meat infusion broth. The swab was placed one-half inch below the surface of the broth medium, the contaminated distal half-inch of the shaft being two inches above the cotton plug used for stoppering the flask. The third swab was placed in a tube of cooked meat medium. Except for the omission of the flask containing 100 cc. of broth, the same procedure was carried out for the fascia and peritoneum. Sterilization of tubes and flasks by flaming was not possible because of the use of ether and ethylene in the operating rooms.

For the purposes of this study the cultures are divided into two groups. The first group of 18 cases consists of the following cultures:

(*a*) Swabs of the skin just after the incision.

(*b*) Swabs in the region of the anterior fascia.

(*c*) Swabs of the parietal and visceral peritoneum immediately after opening the abdomen.

(*d*) Swabs of the parietal and visceral peritoneum just before closure of the peritoneum.

(*e*) Swabs of the anterior fascia during closure of the wound.

(*f*) Swabs of the line of the incision in the skin after closure of the wound.

(*g*) Blood agar plates 10 cm. in diameter exposed to the air in the operating room during each operation. They were placed at the level of the incision, three feet from the actual operative field, and were exposed throughout the entire operation. Many times they were placed upon the sterile drapes.

A second group of 12 cases was cultured with the following technic, modified after Hunt,[11] in an effort to determine the number, rather than the type, of bacteria in the wounds.

(*a*) Skin cultures at the beginning of the operation were made as above with the exclusion of the meat tube cultures which the results of the previous work had shown to be unnecessary.

(*b*) Ten cc. of sterile saline solution were introduced into the region of the anterior fascia, washed about and withdrawn by means of a Dakin syringe. The resultant fluid was then introduced into a sterile test tube, which was placed in a refrigerator until the termination of the operation.

(*c*) Procedure (*b*) was similarly employed at the level of the anterior fascia on closure of the wound.

(*d*) The sutured skin was swabbed and cultured as at the beginning of the operation.

(*e*) At the end of the operation, 1 cc. of each saline wash was placed into melted meat infusion agar and plates were poured.

The cultures were examined after 24 and 48 hours of incubation. The 24 hour examination was a superficial one, recording cloudiness of the liquid

media, and colonies found on the solid media. Transplants were made at 24 hours if growth had appeared, or at 48 hours if the cultures did not show growth before that time. Transplants were made on meat infusion agar plates. Any culture which showed no growth in 48 hours was discarded. Transplants in the second group of cases were deemed unnecessary.

The fluid media were routine bacteriologic meat infusion broth and tubes of cooked meat. Solid media consisted of routine bacteriologic meat infusion agar plates, blood agar plates and plain meat infusion agar which was used for the pour plates. The swabs were composed of a wooden stick tipped with cotton. Twelve to 18 of these swabs were placed in a large glass tube wrapped in heavy brown paper and sterilized in the autoclave. When used, the tube was unwrapped and dropped on the nurse's sterile table. Swabs were removed as needed from the tube by the nurse, and the tube was capped with a sterile cotton plug when not in use.

Smears of the bacteria from the colonies were made and stained by Gram's method when identification by colony type was impossible or doubtful. Similar preparations were made from each fluid culture. Because of lack of time, it was impossible to carry out virulence tests and biochemical identification of the organisms.

The results obtained in the total of the 30 cases referred to above are most easily appreciated when tabulated according to the various layers of a wound, *i.e.*, skin, fascia and peritoneum. We have, therefore, arranged them in this order and have also compared the bacteria found at a given layer early in the course of an operation with those found in the same area at the close of the procedure.

The data derived from the skin cultures of all 30 cases are detailed in Table I, as the same method of culturing the skin was used throughout the research. In Tables II and III, *i.e.*, those dealing with the fascia and peritoneum, only the data from the first 18 cases were included. The data from the second group of 12 cases were omitted as the results of this group, in which an attempt was made to determine the approximate number of organisms at the fascial levels, were disappointing. A satisfactory quantitative estimation of the organisms was not obtained although large numbers of bacteria were recovered and contamination of the fascia was adequately demonstrated.

The skin was cultured in 30 cases at the beginning of the operation after it had been prepared and draped. The preparation consisted of washing several times with sterile liquid soap and water followed by 70 per cent alcohol and then several coats of kalmerid (1 per cent potassium mercuric iodide in 85 per cent acetone and 15 per cent water with enough eosin to color the solution). At the close of the operation the skin was cultured in 29 cases.

In the appended tables, the Roman numeral I refers to the beginning of the operation and the Roman numeral II refers to the close. Thus Skin I means the skin culture at the start of the operation and Skin II refers to the skin culture at the end of the procedure.

Positive cultures were obtained from the skin in 86 per cent of the cases at the start of the operation and in 100 per cent of the cases at the close of the operation. It should be noted, however, that the agar plates were positive in only eight instances, or 26 per cent, of the cases cultured at the onset of

TABLE I

	Skin I		Skin II	
	Number of Cases	Percentage of Contamination	Number of Cases	Percentage of Contamination
Total cultures	30		29	
Total positive cultures	26	86	29	100
Total positive plate cultures	8	26	23	76
Cultures positive for Staphylococci	24	80	29	100
Plate cultures positive for Staphylococci	6	20	22	73

the operation, but were positive in 23, or 76 per cent, of the 29 cases at the close of the operation. This indicates a greater increase in the number of bacteria occurring on the skin at the close of the operation than would be expected from the figures compiled from all three media, the reason being that the liquid culture method is more sensitive than the plate method.

It is also interesting to note that only six instances, or 20 per cent, of the plate cultures were positive for Staphylococci at the onset of the operation, but 22, or 73 per cent, were positive at the close. These figures indicate that the skin is far from sterile at the beginning of the operation and is very heavily contaminated at the close of the procedure (Table I).

In Table II, Fascia I has been compared with Fascia II. The comparison was made in a group of 18 cases in which the method of culture was constant.

TABLE II

	Fascia I		Fascia II	
	Number of Cases	Percentage of Contamination	Number of Cases	Percentage of Contamination
Total number of cultures	18		17	100
Total positive cultures	8	44	14	82
Total positive Staphylococci cultures	7	38	13	76

Positive cultures were obtained from the fascia in 44.4 per cent of the cases at the start of the operation as opposed to 82.3 per cent of the cases at the close of the procedure, indicating that the number of organisms in the wounds increased with the length of the operation and that the fascial layer is heavily contaminated.

The figures in Table III have been compiled from the peritoneal cultures. (One culture was taken of the periosteum as a substitute for one of the

peritoneum in the thoracoplasty wound.) Seven of the 18 cases were herniorrhaphies and as the peritoneum was exposed only for a few moments in these cases only one peritoneal culture was obtained. The group of cultures representing Peritoneum II, therefore, consists of only 11 cases, while Peritoneum I is represented by 18 cases.

TABLE III

	Peritoneum I		Peritoneum II	
	No. of Cases	Percentage of Contamination	No. of Cases	Percentage of Contamination
Total number of cultures.	18		11	100
Total positive cultures...	11	61	10	90
Cultures positive for Staphylococci.....	3	16	7	63

Peritoneum I and Peritoneum II produced 61.1 and 90.9 per cent positive cultures, respectively.

Table IV summarizes the preceding tables and, in general, it may be seen that contamination increases with the time of the operation. Thus Peritoneum II, Fascia II and Skin II all yielded more organisms than Peritoneum I, Fascia I and Skin I.

TABLE IV

	No. of Cases	No. of Positive Cultures	Percentage of Positive Cultures	No. of Cultures Positive for Staphylococci	Percentage of Cultures Positive for Staphylococci
Skin I.....	30	26	86	24	80
Skin II.....	29	29	100	29	100
Fascia I.....	18	8	44	7	38
Fascia II.....	17	14	82	13	76
Peritoneum I.....	18	11	61	3	16
Peritoneum II.....	11	10	90	7	63

Many of the organisms found in these wounds come from the skin, as has been shown by the number of positive skin cultures at the beginning of the operation. It is believed, however, that the majority of these bacteria come from the atmosphere and either fall directly into the wound or are carried there by sponges, hands, solutions or other material that has been exposed to the air. This contamination with bacteria from the air may have contributed to the number of positive skin cultures at the beginning of the operations.

Table V shows the results of cultures on 22 plates which were exposed to the air of the operating room while the operations were in progress. No attempt was made to make more than a superficial identification of the organisms.

An analysis of this group of cultures shows that the various types of

Staphylococci together constituted a majority of the organisms present in the operating room air. This agrees well with the results obtained by Meleney,[15] Hunt,[11] Hart,[10] and Carnes.[4] All of these workers have found Staphylococci to be the most prevalent organisms in the air of their operating rooms.

The presence of large numbers of Staphylococci in the operating room air is not without significance, for they, as has been shown above, may be recovered from the wounds at operation, and, as will be seen later, cause 50 to 70 per cent of all wound infections.

TABLE V

ATMOSPHERE EXPOSURE PLATES

Total number of plates exposed	22	
Average percentage *Staphylococcus aureus*	6.9%	88.4%
Average percentage *Staphylococcus albus*	81.5%	
Average percentage remainder (sporing rods, diphtheroids, yeasts, molds, *etc.*)	11.6%	
	100.0%	

It is interesting and important to know that in spite of the fact that many bacteria were recovered from all of the wounds, infection developed in only one. This, a left inguinal herniorrhaphy wound, healed by primary intention, and the patient was discharged as cured after 16 days. Approximately two weeks later, he returned with a deep undermining abscess beneath the scar. The infection involved the entire length of the original wound and descended to the deep fascia. Cultures and smears of the pus revealed *Staphylococcus albus.*

All wounds are heavily contaminated with bacteria presumably from the skin of the patient and the air of the operating room. Many of these organisms are known to be nonpathogenic but the Staphylococci form a not inconsiderable portion of the total. In spite of the presence of these bacteria, only about 5 per cent of the wounds become infected, so that factors other than the mere presence of bacteria, such as the resistance of the patient and the condition of the wound itself, must play an important rôle in the development of infection.

However, if the Staphylococci as a group are responsible for the majority of wound infections, one may rightly assume that the contamination of wounds with these organisms is the cause of many postoperative wound infections. Our inability to reduce the incidence of infection below 5 per cent may well be due to neglect of this source of contamination. A study of the types of organisms that are actually present in infected wounds is, therefore, of considerable interest.

All of the wound infections occurring in patients on the Surgical Ward Service of the New Haven Hospital from July, 1934, to April, 1937, were reviewed. For the purposes of this study the authors included all wounds which were closed without drainage of any kind. As shown in Table VI, there were 72 infected wounds; 39 of these, or 54 per cent, yielded Staphylo-

cocci alone upon culture. Staphylococci were present in conjunction with other organisms in three cases.

TABLE VI

Total cases	1361	
Total wound infections	72	
Percentage of wound infections		5.29%
Bacteria obtained in pure culture:		
Staphylococcus albus	22	
Staphylococcus aureus	17	
Nonhemolytic Streptococcus	2	
Hemolytic Streptococcus	2	
B. coli communis	9	
No cultures	14	
Diphtheroids	1	
	67	
Mixed Infections		
Staphylococcus albus + *Clostridium welchii*	2	
Staphylococcus aureus + *Clostridium welchii*	1	
Bacillus coli + unidentified gram-positive Coccus	1	
Hemolytic Streptococcus + *Staphylococcus albus*	1	
	5	Total 72

In this series all of the *B. coli* infections occurred in appendicectomy wounds. The contamination of the subcutaneous tissues in these cases with infected material from the abdomen is obvious and these infections cannot be ascribed to a fault in the aseptic technic. If these *B. coli* infections are eliminated there remain 63 wound infections of which *Staphylococcus albus* caused 22, or 35 per cent, and *Staphylococcus aureus* 17, or 27 per cent. The *Staphylococci* together are responsible for 62 per cent of the infected wounds.

Beckman,[1] in 1914, in a review of the complications occurring in a series of 6,825 operations performed at the Mayo Clinic during the year 1913, presented a series of 117 wound infections. Cultures had been taken of 110 of these infected wounds. In 75, or 68 per cent, of the infections, pure cultures

TABLE VII

INFECTING ORGANISMS CULTURED FROM 75 CASES OF INFECTED WOUNDS AT THE MAYO CLINIC[1]

Organism	No. of Cases	
Bacillus coli communis	19	
Staphylococcus albus	18	46, or 61%, of total
Staphylococcus aureus	21	
Staphylococcus citreus	7	
Pneumococcus	2	
Streptococcus	3	
Bacillus subtilis	2	
Miscellaneous	3	
	75	

of various organisms were obtained (Table VII), while in 35, or 31 per cent, several kinds of bacteria were found.

In this series Staphylococci were recovered from 61 per cent of the infections in which only one organism was present, and of the 35 wound infections in which several organisms were found, Staphylococci were present in conjunction with the other organisms in all but seven cases.

Meleney,[14] in 1930, at the Presbyterian Hospital, New York City, cultured all of the infected wounds on the Surgical Service (Table VIII).

TABLE VIII

RELATIVE INCIDENCE OF INFECTING ORGANISMS CULTURED FROM INFECTED WOUNDS AT THE PRESBYTERIAN HOSPITAL, NEW YORK[14]

Organism	Percentage of Occurrence	
Hemolytic Streptococcus	4	
Nonhemolytic Streptococcus	10	
Hemolytic *Staphylococcus aureus*	15	57
Staphylococcus aureus	20	
Staphylococcus albus	22	
B. coli	7	
B. subtilis	6	
B. proteus	1	
B. pyocyaneus	1	
Diphtheroids	5	
Others	4	
	95	

In this series the Staphylococci again are seen to comprise over one-half of the organisms found in the infected wounds.

Eliason and McLaughlin[6] isolated from their Type C (serious) wound infections the appended infecting organisms (Table IX). It will be noted that the Staphylococci caused 50 per cent of them.

TABLE IX

Organism	No. of Cases
Staphylococcus	5
Hemolytic Streptococcus	1
C. welchii	1
B. coli	2
Anaerobes (not gas)	1
	10

Discussion.—A study of our own figures and of those we have been able to collect from the literature justifies the conclusion that well over 50 per cent of postoperative wound infections are caused either by *Staphylococcus aureus* or *Staphylococcus albus*. It has been shown that these organisms are present in the air of the operating room and on the skin of the patient. They unquestionably contaminate wounds during operations, and they may be recov-

ered from the wounds by suitable culture methods. If contamination of wounds by these bacteria from the air and skin could be eliminated, the incidence of infected wounds would be much lower.

In this connection the work of Wells and his collaborators, [20 to 24] on air borne infection is of considerable interest. They have shown that many of the common pathogenic bacteria are capable of surviving in the air for considerable lengths of time. *Staphylococcus aureus*, a common invader of clean wounds, if sprayed into the air according to the technic of Wells, may be recovered after as long as three days. Not only are many bacteria able to live for several days in the air, but when they are sprayed into the air from an atomizer or from the throat by coughing, sneezing or talking, the majority do not settle out quickly but remain suspended almost indefinitely. The air currents waft them about and disseminate them widely. Wells has demonstrated this dissemination by inoculating with *Bacillus coli* the water in the humidifier of a one room air conditioner in the basement of the Harvard School of Public Health. The remainder of the building was not mechanically ventilated, yet they were able to recover the organism from the air at the end of every corridor in the building, and on the third (top) floor the bacteria were present in a concentration approximately 1 per cent of that in the air conditioned room.

Wells and Wells[24] briefly discuss the effect of ultraviolet radiation upon bacteria suspended in the air and state that it may be possible to sterilize the air of public buildings with radiant energy in conjunction with other methods such as filtration.

Hart[10] has attempted to sterilize the air in his operating room with ultraviolet light. He tried this because of the high percentage of staphylococcal infections that were occurring in his thoracoplasty wounds. No source other than the operating room air could be found for these bacteria and after an ultraviolet lamp capable of sterilizing the air about the operating table was installed, a prompt decrease was noted in the incidence of infections.

Gudin[9] has also emphasied the importance of contamination by bacteria from the air as a cause of wound infection. This observer was so disturbed by the number of infections occurring in his clean cases that he carefully reviewed all phases of his technic. In spite of the strictest attention to the usual details of aseptic technic he was unable to reduce the incidence of wound infection. The air of the operating room seemed to be the only possible source of the bacteria. In order to eliminate this avenue of contamination, he devised an air-tight operating room ventilated only by air which had been chemically sterilized. The members of the operating team were required to change into sterile gowns in an adjoining room so they would not contaminate the sterile air with bacteria from their skin and clothing. Although Gudin presents no statistics, he states that infection practically disappeared and the wounds healed with surprisingly little reaction after adoption of the sterilized air technic.

The methods which have been used to sterilize air in the operating room

are as yet clumsy and difficult to employ but we believe that until a satisfactory method of preventing the contamination of wounds with Staphylococci from the air of the operating room is developed, wound infections will continue to occur.

SUMMARY

(1) A review of the literature reveals that about 5 per cent of clean surgical wounds become infected.

(2) Cultures of a series of wounds taken during the actual operations showed all of them to be extensively contaminated with bacteria, among which Staphylococci predominated.

(3) Most of the bacteria which were recovered from the wounds at operation come from the skin of the patient or the air of the operating room.

(4) The majority of postoperative wound infections are caused by bacteria similar to those which were isolated from the wounds at operation.

(5) Any improvement in surgical technic which will decrease the contamination of operative wounds by bacteria from the air of the operating room or the skin of the patient should result in a decrease in the incidence of postoperative wound infection.

REFERENCES

[1] Beckman, E. H.: Complications Following Surgical Operations. Surg., Gynec., and Obstet., **18**, 551–555, May, 1914.

[2] Bowman, F. H.: Asepsis of Abdominal Incisions. U. S. Nav. Med. Bull., **14**, 208, April, 1920.

[3] Brewer, G. C.: Studies in Aseptic Technique. J.A.M.A., **64**, 1369–1372, April 24, 1915.

[4] Carnes, E. H.: Prevention of Postoperative Wound Infections. Pub. Health Rep., **49**, part 2, 939–944, August 10, 1934.

[5] Coley (quoted by Sutton): New York State Jour. Med., **28**, 129–132, February 1, 1928.

[6] Eliason, E. L., and McLaughlin, C.: Post-operative Wound Complications. ANNALS OF SURGERY, **100**, 1159–1176, December, 1934.

[7] Foss, H. L.: Checking and Controlling Postoperative Infections. Bull. Am. Coll. Surgeons, **18**, 40, December, 1934.

[8] Goff, B. H.: An Analysis of Wound Union in 3,000 Abdominal Incisions Based on Woman's Hospital Classification of Wounds and Wound Union. Surg., Gynec., and Obstet, **41**, 728–739, December, 1925.

[9] Gudin, M.: Asepsie fictive et sterilisation totale. Presse Med., **44**, 355–359, March 4, 1936.

[10] Hart, D.: Sterilization of the Air in the Operating Room by Special Bactericidal Radiant Energy; Results of Its Use in Extrapleural Thoracoplasties. Jour. Thor. Surg., **6**, 45–81, October, 1936.

[11] Hunt, E. L.: Some Further Observations upon Contamination of Operative Wounds by Air-borne Bacteria. New England Jour. Med., **209**, 931–933, November 9, 1933.

[12] Irwin, F. G., and Pla, J.: Clean Wound Surgery in Hot Climates. Am. Jour. Surg., **33**, 220–222, August, 1936.

[13] Macfarlane, C.: Infection of the Abdominal Incision; Incidence in 500 Gynecologic Laparotomies. Am. Jour. Obst. and Gynec., **2**, 630–632, May, 1926.

[14] Meleney, F. L.: The Control of Wound Infections. ANNALS OF SURGERY, **98**, 151–153, July, 1933.

[15] Meleney, F. L.: Infection in Clean Operative Wounds; a Nine Year Study. Surg., Gynec., and Obstet., **60,** 264–276, February (No. 2A), 1935.

[16] Roberts, K., and Roberts, G. W.: Abdominal Incisions Treated by the "Open Method." ANNALS OF SURGERY, **85,** 822–826, June, 1927.

[17] Sutton, H. B.: Inadequate Skin Preparation as a Cause of Postoperative Infection. New York State Jour. Med., **28,** 129–132, February 1, 1928.

[18] Thorek, Max.: The Etiology, Prevention and Treatment of Postoperative Wound Infections. Illinois Med. Jour., **50,** 477–483, December, 1926.

[19] Valdes, Ulises: Treatment of Incisions by the Open Method. Surg., Gynec., and Obstet., **53,** 69–70, July, 1931.

[20] Wells, W. F.: On Air-borne Infection: I. Apparatus for the Study of the Bacterial Behavior of Air. Am. Jour. Pub. Health, **23,** 58–59, January, 1933.

[21] Wells, W. F.: On Air-borne Infections: II. Droplets and Droplet Nuclei. Am. Jour. Hyg., **20,** 611–618, November, 1934.

[22] Wells, W. F., and Fair, G. M.: Viability of *B. coli* Exposed to Ultra Violet Radiation in Air. Science, **82,** 280–281, September 20, 1935.

[23] Wells, W. F., and Stone, W. R.: On Air-borne Infection: III. Viability of Droplet Nuclei Infection. Am. Jour. Hyg., **20,** 619–627, November, 1934.

[24] Wells, W. F., and Wells M. W.: Air-borne Infection. J.A.M.A., **107,** 1698-1703, November 21, 1936; Air-borne Infection; Sanitary Control. J.A.M.A., **107,** 1805–1809, November 28, 1936.

[25] Whipple, A. O.: The Use of Silk in the Repair of Clean Wounds. ANNALS OF SURGERY, **98,** 662–671, October, 1933.

BRIEF COMMUNICATIONS AND CASE REPORTS

HYPERTENSION EXPERIMENTALLY PRODUCED BY CONSTRICTING THE ARTERY OF A SINGLE TRANSPLANTED KIDNEY*

ADDITIONAL OBSERVATIONS

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IN A recent paper[1] dealing with the experimental production of hypertension, a series of experiments on dogs were reported which demonstrated that a transient elevation of blood pressure was produced by constricting the artery of a single transplanted kidney. Three of the eight dogs subjected to this experiment were alive when the preliminary report was published. The observations on these three dogs, continued for six additional months, show that in each a permanent hypertension developed.

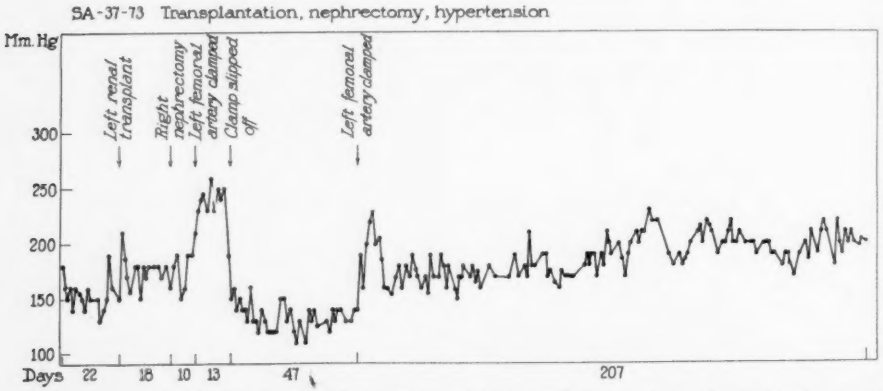

CHART 1.—*Experiment V* (Dog SA-37-73): Constriction of femoral artery; rise in blood pressure from 140 to 240 Mm. Hg.; blood pressure maintained at 240 Mm. Hg. for eight days, then sudden fall to 130 Mm. Hg. Roentgenologic examination showed that the clamp had slipped off the artery. Further constriction of the femoral artery; rise in blood pressure from 130 to 230 Mm. Hg.; return to 160 Mm. Hg. The blood pressure remained between 160 and 190 Mm. Hg. for a period of two months and then slowly began to rise to a level of nearly 200 Mm. Hg. which has been maintained for over four months. The animal is living and well, ten months after the transplantation of the kidney.

Method.—By means of a Van Leersum carotid loop, daily observations of the blood pressure were made for one month or more to determine the average normal level for each dog. The left kidney was then transplanted to the groin by the following technic: The femoral artery and vein were dissected free in the groin; the peritoneal cavity was entered through an in-

* Done under a grant from the John and Mary Markle Foundation. Submitted for publication December 10, 1937.

cision extending from Poupart's ligament to the costal margin. Through this wound the kidney was freed and its vessels divided. By sufficient mobilization of the ureter the kidney could be brought down and fixed in the groin without tension. Its blood supply was reestablished as quickly as possible by an end-to-end anastomosis of the renal and femoral vessels. The abdominal wound was closed over the transplanted kidney. Following this pro-

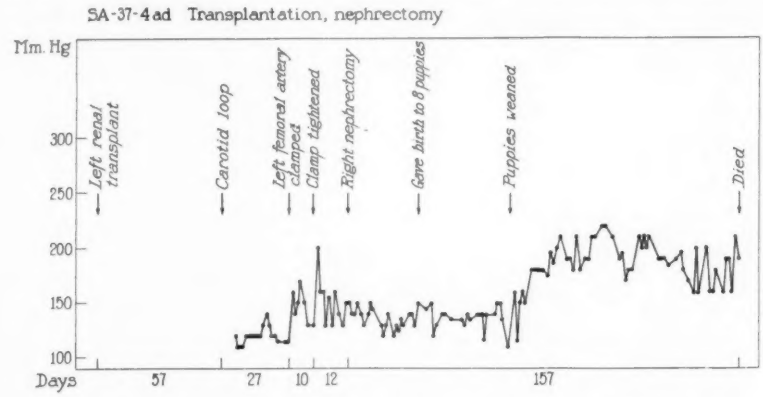

CHART 2.—*Experiment VI* (Dog SA-37-4ad): Constriction of femoral artery; rise in blood pressure from 120 to 170 Mm. Hg.; return of blood pressure to 130 Mm. Hg. Further constriction of femoral artery; rise in blood pressure from 130 to 200 Mm. Hg.; return to 130 Mm. Hg.; right nephrectomy. Animal gave birth to eight puppies. Blood pressure remained between 130 and 150 Mm. Hg. until puppies were weaned when it began steadily to rise, reaching a level of 190 to 210 Mm. Hg. which was maintained for a period of almost four months. Animal then became uremic and died during a convulsion. Autopsy revealed gross infarction of the kidney secondary to erosion of the vessel by the silver clip.

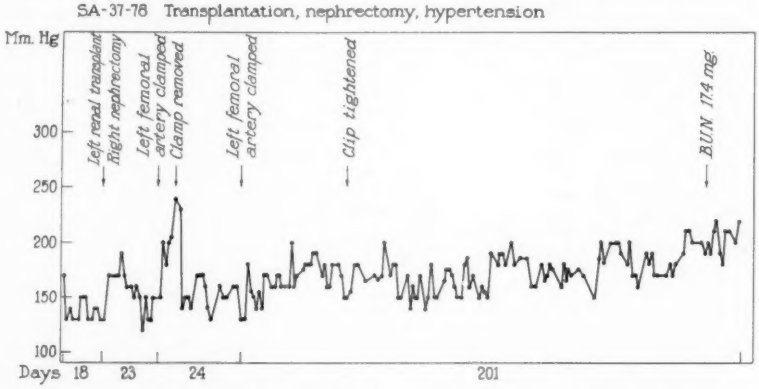

CHART 3.—*Experiment VIII* (Dog SA-37-7B): Constriction of the femoral artery; rise in blood pressure from 130 to 260 Mm. Hg.; symptoms of acute intoxication necessitated the removal of the clamp; complete recovery. Further constriction of the femoral artery; rise in blood pressure from 140 to 180 Mm. Hg.; return to 150 Mm. Hg.; then a gradual rise in blood pressure to a level between 170 and 200 Mm. Hg. which is maintained. Animal living and well nine and one-half months after transplantation of the kidney.

cedure the blood pressure was recorded daily for approximately three weeks to determine the effect of the operation upon the level of blood pressure. The second kidney then was removed and blood pressures recorded for ten more days. At the expiration of this period the artery of the transplanted kidney was constricted by means of a Goldblatt clamp or other method.

Brief protocols and corresponding charts are submitted for the three dogs

which survived the experiment. A composite chart has been introduced to show the highest and lowest pressures observed in the three dogs during the various stages of the experiments.

Summary.—It will be seen from the protocols and composite chart that the hypertension produced in these dogs by constricting the artery of a single transplanted kidney appeared at first to be transient. Within two months after the application of the clamp, however, the blood pressure rose to a definitely hypertensive level and remained there as long as the observations were continued.

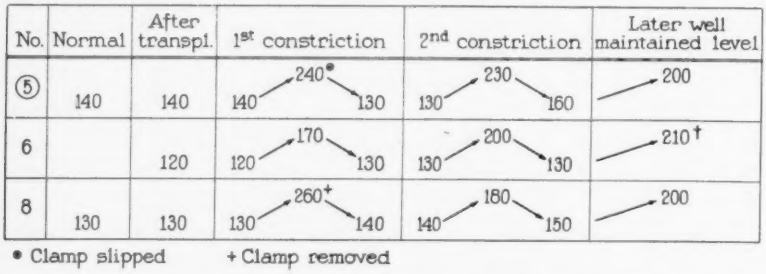

CHART 4.—Composite representation of blood pressure changes produced in the preceding three experiments.

DISCUSSION.—The experiments upon the transplanted kidney were undertaken in the hope of establishing the rôle played by the renal nerves in the development and maintenance of hypertension in experimental animals. Our observations seem to indicate that they play no important part in the initiation or maintenance of this type of hypertension. The question may be raised as to whether the nerves might have regenerated following transplantation. It is difficult to believe that complete regeneration could take place during the period of observation. The fall in blood pressure following the immediate rise after constriction of the artery of the transplanted kidney still awaits explanation.

REFERENCE

[1] Glenn, F., Child, C. G., and Heuer, G. J.: Production of Hypertension by Constricting the Artery of a Single Transplanted Kidney. ANNALS OF SURGERY, **106**, 848, November, 1937.

THE USE OF SULFANILAMIDE IN THE TREATMENT OF BRAIN ABSCESS

REPORT OF TWO CASES

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RECENT clinical and experimental reports of the efficacy of sulfanilamide in the treatment of pneumococcic and streptococcic infections led us to use

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this drug in two cases of brain abscess. Because active surgical therapy was instituted at the same time, the effects of the drug were somewhat difficult to evaluate, but the initial condition of each patient was so poor and the results of treatment so satisfactory, that the experience seemed to warrant reporting.

Case 1.—F. H., white, male, age 14. Hospital No. 8472. Admitted March 3, 1937. Discharged April 2, 1937.

History.—The patient had suffered occasional attacks of left otitis media for eight years, but had been symptom free for two years, when his present illness began, February 16, 1937, with an earache. The drum was opened promptly, a small amount of pus evacuated, and all symptoms and signs referable to the ear disappeared very rapidly. Four days later, however, fronto-occipital headaches appeared and became progressively worse. The patient became drowsy and irritable, complained of photophobia, and, after about ten days, grew stuporous. It was observed that he was somewhat awkward in using his hands—particularly the left.

On admission to the Homestead Hospital, his temperature was 100° F. (by rectum), pulse 150, respirations 14. The temperature became normal after a few hours, but the pulse remained rapid and the respirations occasionally dropped to ten and eight per minute. Lumbar puncture showed an increased cerebrospinal fluid pressure, 50 cells (largely polymorphonuclear) per cmm., and no organisms. At this time, two weeks after the otitis media, the patient was referred to us by Dr. L. P. Losa and Dr. W. E. Brown, of Homestead, Pa.

Examination.—Neurologic examination showed the following: (1) The patient was semistuporous and slept when not disturbed, but could be aroused by painful stimuli to a state in which he would obey simple commands and answer simple questions with monosyllables. He was quite irritable and preferred being left alone. (2) The right pupil was larger than the left, but both reacted normally. Both eyes tended to turn to the right, and the patient could not carry out conjugate movement to the left past the fixation point, although other extra-ocular movements were normal. The optic disks were not raised, although the retinal veins were congested. (4) The tendon reflexes in the legs were hyperactive, and a bilateral sustained ankle clonus, Oppenheim, and Babinski reflexes were present. (5) Finger to nose test on the left was performed very awkwardly. (6) The left suboccipital region was tender to percussion and firm pressure. (7) On extreme flexion of the neck, some stiffness was noted, but Kernig and Brudzinski reflexes were not present.

Operation.—First Stage: March 2, 1937. It was decided to confirm the diagnosis of left cerebellar abscess by ventricular estimation, and at the same time temporarily reduce the very high intracranial pressure. This procedure disclosed symmetrically dilated lateral ventricles, apparently placing the lesion in the posterior cranial fossa. Accordingly, through a vertical incision, the bone over the left cerebellar hemisphere was exposed, and an opening 4 cm. in diameter made. A canula introduced into the cerebellum met slight resistance at a depth of 4 cm. The dura was opened widely, the wound was lightly packed and closed loosely.

The patient improved slightly for about 24 hours, and was transferred to the Western Pennsylvania Hospital. About 36 hours after the first operation, however, he became completely unconscious and developed such marked signs of medullary compression in spite of repeated ventricular tap, that drainage of the abscess seemed imperative.

Operation.—Second Stage: March 3, 1937. The patient's wound was reopened, the edges of the exposed cerebellar cortex were sealed to the arachnoid with the electric coagulation and an effort was made to remove the small cortical fungus which had developed and a core of brain tissue down to the abscess wall. Because of the depth of the lesion and the limited size of the opening in the bone, it was not possible to expose

the capsule. Accordingly, a small tube was introduced into the abscess. It was possible to aspirate 20 cc. of pus with a syringe and about an equal amount escaped spontaneously. The wound was closed loosely with silkworm gut, and the tube sutured to the skin edge.

Sulfanilamide Therapy.—The patient was given a subcutaneous injection of 5 cc. of prontosil within an hour after the operation, a dose which was repeated in 12 hours and again in 36 hours. On the day following operation, prontylin, grains ten every six hours, was begun by mouth and continued for five days. During this time, examination of the ventricular and spinal fluid disclosed the presence of the drug in a concentration only slightly less than that in the blood.[1] Because the patient began to experience nausea and vomiting, the dosage was reduced to grains five every six hours for two days, when the medication was discontinued.

Antipneumococcus Therapy.—Culture of the pus removed from the abscess showed a pure growth of Type V pneumococcus* (Table I). Accordingly, antipneumococcus serum of this type (Lederle) was given intravenously in dosages of 20,000 units every 12 hours, until a total of 220,000 units had been administered.

TABLE I

RESULTS OF SERIAL SMEARS AND CULTURES FROM ABSCESS IN CASE I

Date	Smear	Culture
3-3-37	Abscess drained	
3-3-37	Diplococci	Pneumococci Type V (pure culture)
3-5-37	Diplococci	Pneumococci Type V (pure culture)
3-8-37	Staphylococci	Staphylococcus albus pure culture. No pneumococci present
3-11-37	Staphylococcus predominating. Penumococcus present	Staphylococcus and pneumococcus
3-13-37	Few organisms present. Staphylococcus and pneumococcus. More phagocytosis	
3-18-37	Negative	Hemolytic *Staphylococcus albus*. No pneumococcus present
3-20-37	Negative	
3-23-37	Numerous Staphylococci	Partially hemolytic *Staphylococcus albus*
3-29-37	Negative	All cultures negative
3-29-37	Drainage tube removed	

Course.—Five days after the drainage of the abscess, Staphylococci were found in the smear from the discharge. Accordingly, the tube was irrigated daily with Dakin's solution. The tube in the abscess was gradually shortened beginning on the third post-operative day. When the discharge ceased, and culture from the depths of the tube was negative, on the twenty-sixth day, the remaining two inches of tubing were removed. The wound in the superficial tissues healed rapidly within the next few days.

From a clinical standpoint, the patient improved slowly at first. He remained very somnolent for four days, although he could be aroused promptly by mild stimuli. The nystagmus, the dysynergia on the left, and the pyramidal tract signs on the right remained constant, although the conjugate eye movements to the left did begin to return somewhat. Eleven days after operation, the patient's general condition was much improved, he was out of bed daily, his cerebellar signs were beginning to lessen, and his

* We are indebted to Dr. Philip Hadley and his staff in the Department of Bacteriology of the Western Pennsylvania Hospital for the very numerous and extremely helpful bacteriologic studies in both of the cases reported.

headaches had disappeared. In another week still further gains were made, and at the time of his discharge, one month after operation, only very slight awkwardness of the left extremities was present.

Follow-Up.—Examination three months postoperative disclosed no evidence of intracranial pathology. The patient was symptom-free with two exceptions: (1) His parents reported occasional periods of irritability and sulkiness; (2) the boy had observed that if he extended his head far backward, he became dizzy. He had noticed no impairment of coordination and could run, play golf, and ride a bicycle.

SUMMARY.—Left otitis media followed in five days by headaches, awkwardness of left hand, stupor. Left cerebellar abscess drained two weeks after initial ear infection. Sulfanilamide begun immediately. Twenty-six days later drainage ceased, and tube was removed. Follow-up examination three months later showed no evidence of cerebellar pathology.

Case 2.—J. G., white, female, age 10. Hospital No. 9312. Admitted March 30, 1937. Discharged June 4, 1937.

History.—After suffering with a draining left ear for several months, the patient began to complain of headache. Within three days it was observed by the family that she tended to keep her head and eyes turned to the right. Two days later, she became stuporous and was referred to us by Dr. Roger E. Phillips of Philipsburg, Pa.

Examination.—On admission, the child appeared extremely ill. She was deeply unconscious, quite dehydrated, had a temperature of 105° F. by rectum, pulse 144. There was a purulent discharge from the left ear. The head and eyes were fixed to the right. The neck was stiff, and Kernig's sign was very definite on both sides. The left pupil was smaller than the right. No papilledema was present. The patellar reflexes were hyperactive, and ankle clonus and Babinski reflexes were present bilaterally. Lumbar puncture showed a pressure of 10 Mm. of mercury (in the horizontal position), the fluid containing 300 white cells per cmm., but showing no organisms.

It was felt that the patient had a left cerebellar abscess, and that both because a generalized meningitis seemed imminent and because of the high intracranial pressure (presumably the spinal pressure was low because of a posterior fossa cerebrospinal fluid block), drainage of the abscess should be carried out without delay. She was given 500 cc. of a 20 per cent sucrose in physiologic saline intravenously, prontosil 5 cc. hypodermically, and prontylin grains ten by rectum, preoperatively.

Operation.—As a preliminary diagnostic measure, both lateral ventricles were tapped and found to be enlarged. The left cerebellar hemisphere was then exposed through a bone opening 4 cm. in diameter and a similar opening in the dura mater. In spite of the previous drainage of 20 cc. of cerebrospinal fluid from the ventricular system, there was a marked increase in pressure in the posterior cranial fossa. Gentle palpation with a brain canula revealed a sense of resistance 3 cm. beneath the surface. An attempt was made to expose the abscess, using the Bovie loop to remove the overlying cerebellar tissue, but as in the previous case, the small size of the bone opening rendered this impossible. It was then thought that the lesion might be allowed to herniate toward the decompression for 24 hours or more. At this point, however, the child became slightly restless, and cyanotic, her respirations slowed markedly, and the veins of the cerebellum in the operative field became very congested. As it seemed probable that serious medullary damage might occur very soon unless the pressure in the posterior cranial fossa were reduced, the margins of the dural opening were coagulated, and a small drainage tube was introduced into the abscess. Between 20 and 30 cc. of very foul smelling pus escaped at once under considerable pressure. The tube was sutured to the side of the skin opening and the wound loosely closed over a small amount of gauze packing. The signs of medullary embarrassment disappeared promptly after the drainage of the abscess.

Sulfanilamide Therapy.—The early smears of the pus disclosed a considerable variety of organisms, but on culture it was apparent that the predominating one was of the

Friedländer group. Since the meager data in the literature concerning the effect of sulfanilamide upon the Friedländer bacillus were at least partly favorable, and since Streptococci were present in the pus as well, the drug was continued for 35 days, grains ten being given twice daily for two weeks and then grains five twice daily for the next three weeks.

Course.—The drainage tube was shortened slowly, beginning on the ninth postoperative day, the rate of withdrawal being governed by the amount of discharge, the bacteriologic studies (Table II), and the clinical condition of the patient. On the twelfth postoperative day, cerebrospinal fluid began to drain from the wound around the drainage tube. This continued for 48 hours before the ventricular and spinal drainages, which were instituted immediately, resulted in a sealing-off of the leak. Several examinations of the cerebrospinal fluid at this time showed a normal cell count and no growth on culture. The tube was removed entirely 24 days after operation, and the wound then healed rapidly.

TABLE II

RESULT OF SERIAL SMEARS AND CULTURES FROM ABSCESS IN CASE 2

Date	Smear	Culture
3-31-37	Abscess drained. Streptococci, Staphylococci, fusiform bacilli	Gram-negative bacillus of Friedländer group
4-2-37	As before	As before
4-5-37	Few Streptococci. Friedländer type predominating	Friedländer type only
4-11-37	As before	Friedländer type with few Streptococci
4-12-37	Gram-positive diplococci (mostly phagocytosed). Number about the same	Friedländer type only
4-16-37	Gram-positive diplococci (mostly phagocytosed). Number less than on previous examination	Friedländer type only
4-19-37	Gram-positive diplococci (phagocytosed in large numbers). Few gram-negative bacilli	Friedländer type only
4-21-37	Very few gram-positive diplococci	Negative after 48 hrs.
4-23-37	Drainage tube removed	

For 24 hours the patient remained semi-stuporous, though she could be aroused. She slowly reached a normal level of consciousness during the next six days. The conjugate eye movements returned to normal within the first ten days after operation. The left-sided dysynergia, which was quite marked at this time, began to lessen slowly, and by the time the drainage from the abscess had ceased, was almost entirely absent. For some weeks the patient displayed a peculiar, shy, sullen mental attitude which seemed in part attributable to her intracranial pathology.

Cultures from the left ear showed an organism of the Friedländer type, and otoscopic examination disclosed several polypi in the external canal and a large perforation of the drum. On roentgenologic examination, the left mastoid showed no air-containing cells and a small area of decreased density suggesting some bone destruction. May 30, one week after the healing of the cerebellar abscess, a partial radical mastoidectomy on the left was performed by Dr. L. L. Darsie. Culture from the mastoid again showed the Friedländer organisms. The patient's convalescence was uneventful, and the drainage from the ear subsided steadily during the next few weeks. At the time of her discharge from the hospital, June 4, 1937, the mastoid and cerebellar wounds were well healed,

there was only a small amount of exudate from the left ear, and neurologic examination was entirely negative.

Follow-Up.—One month after discharge the patient was symptom free and showed no evidence of intracranial pathology on neurologic examination.

SUMMARY.—Chronic left otitis media for three or four months, followed by progressive headaches and stupor within one week. Drainage tube inserted into left cerebellar abscess. Sulfanilamide begun before operation and continued for five weeks. Recovery from abscess with removal of tube 25 days after operation. Mastoidectomy one month after admission. Symptom-free one month after discharge.

COMMENT.—From the neurologic standpoint, these two cases of left cerebellar abscess had several interesting features in common. Both patients showed a conjugate deviation of the eyes to the side opposite the lesion, and an inability to carry out conjugate movement to the left. It seemed probable that this symptom was the result of pressure from the lesion upon the superior colliculi, since it disappeared in each instance following drainage of the abscess. Such a finding, however, is certainly not a common result of cerebellar disease, and its occurrence in two successive cases seems worthy of remark. We were impressed, too, by the mild but definite mental symptoms, consisting principally of negativism and irritability, displayed at times during their convalescence, by these patients. Such changes have been observed, of course, in cases of cerebral abscess and of cerebellar tumor, so that their occurrence following cerebellar abscess is not surprising. The complete recovery of coordination within two months following extensive cerebellar damage was also most striking.

The surgical problem was primarily that of preventing death from medullary compression and, at the same time, avoiding a generalized meningitis as the result of premature drainage of an early abscess with very little capsule formation. In each instance, despite repeated withdrawal of ventricular fluid and a certain amount of decompression directly over the lesion, the development of dangerously high pressure in the posterior cranial fossa forced the insertion of a drain within ten days of the onset of intracranial symptoms.

The fact that under these conditions meningitis did not develop seemed to be partly attributable to the sulfanilamide, although there is little evidence in the literature to substantiate this action of the drug. In Case 1, the Type V pneumococcus was the predominant organism. While the effects of sulfanilamide upon other pneumococcic infections seem definitely established,[2, 3, 4] there have been no reports concerning pneumococcic brain abscess, and only two rather inconclusive references to pneumococcic meningitis.[2, 3] It is true that antipneumococcic serum was used in Case 1, but in previous similar cases these sera have not proven effective.

In Case 2, meningitis seemed an almost certain complication. The high cell count in the cerebrospinal fluid before operation suggested an impending meningeal involvement, the drainage was carried out in one stage with little chance for protective adhesion formation, and beginning on the twelfth post-

operative day cerebrospinal fluid drained freely from the wound for 48 hours. Again the sulfanilamide may have aided in preventing spread of the infection—although little is known about the effect of the drug upon the Friedländer bacillus. Thus, Levaditi and Vaisman[7] obtained no protection with prontosil (insoluble) in mice infected with this organism. Buttle, *et al.*[8] demonstrated a limited degree of curative action with sulfanilamide in mice infected with the Friedländer bacillus. Bürgers[9] was unable to demonstrate such action with prontosil (soluble) in similarly infected mice.

Finally, the rapid subsidence of the middle ear infection while the brain abscess was progressing in Case 1, and the healing of the cerebellar abscess, in spite of the persistent mastoid and middle ear infection, in Case 2, indicated that in these patients at least, the two lesions had no constant direct connection capable of transmitting the infection, and that the elimination of the source of infection is not always a prerequisite to the successful treatment of an intracranial abscess.

SUMMARY

(1) Two cases of cerebellar abscess successfully treated by continuous drainage and the use of sulfanilamide are reported.

(2) The rapidity and completeness of the patients' recovery, despite their extremely critical preoperative condition, and the early stage at which drainage was of necessity carried out, suggest that the sulfanilamide played an important part in the therapy used, and warrant its further trial in this field.

REFERENCES

[1] Mellon, Ralph R., and Bambas, Louis L.: The Bacteriostatic Effect of Sulfanilamide in the Spinal Fluid of Convalescent Cases of Hemolytic Streptococcus Mennigitis and Pneumococcus Infections. In press: Proc. Soc. Exper. Biol. and Med.

[2] Rosenthal, S. M.: Chemotherapy of Experimental Pneumococcus Infections. Pub. Health Rep., **52**, 48, January 8, 1937.

[3] Cooper, F. B., Gross, P., and Mellon, R. R.: Action of p-aminobenzenesulfanamide on Type III Pneumococcal Infections in Mice. Proc. Soc. Exper. Biol. and Med., **36**, 148, 1937.

[4] Gross, P., and Cooper, F. B.: Efficacy of p-aminobenzenesulfanamide in Experimental Type III Pneumococcal Pneumonia of Rats. Proc. Soc. Exper. Biol. and Med., **36**, 225, 1937.

[5] Forstreuter: Die Bisherigen Erfahrungen mit Prontosil. Deutsch. med. Wchnschr., **62**, 794, May 8, 1936.

[6] Riecke, H. G.: Zur Therapie der Meningitis. Ztschr. f. Hals-Nasen u. ohvenh., **38**, 175, October 22, 1935.

[7] Levaditi, C., and Vaisman, A.: Action curative du chlorhydrate de 4′—sulfamido—2, 4—diamino—azobenzene et de quelques dérivés similaires, dans la streptococcie expérimentale. Compt. rend. Soc. de biol., **119**, 946, 1935.

[8] Buttle, G. A. H., Parish, H. J., McLeod, M., and Stephenson, D.: The Chemotherapy of Typhoid and Some Other Non-streptococcal Infections in Mice. Lancet, **232**, 681, March, 1937.

[9] Bürgers: Chemotherapie der Streptokokken Erkrankungen durch Prontosil, Deutsch. med. Wchnschr., **63**, 672, 1937.

SPONTANEOUS RUPTURE OF THE UTERUS DUE TO HYDATIDIFORM MOLE

REPORT OF A CASE COMPLICATED BY CLOSTRIDIUM WELCHII SEPSIS

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IN A review of the reported cases of spontaneous uterine rupture associated with destructive hydatidiform mole, one is impressed not only by the infrequency of the condition but also by the attendant high mortality. It has long been recognized that an apparently benign mole may occasionally assume a malignant invasive propensity. After eroding the endometrium this type will further involve the myometrium and finally perforate the peritoneal investment of the uterine body.

The dissecting or penetrating mole, *mola hydatidosa destruens,* represents a pathologic alteration of the ovum which has intrigued clinicians and pathologists for many years. It is rather generally agreed that serious uterine damage such as perforation resulting from hydatid moles which are not distinctly neoplastic is extremely rare. The occurrence of a case complicated by a *C. welchii* sepsis was considered unusual enough to warrant reviewing the subject and reporting a personal experience.

Classification.—Ewing[8] groups the entity of hydatid mole under the heading of *choriomata* and then postulates three histologic variations:

(1) Chorio-adenoma destruens—the invasive type of growth which is also known as *mola hydatidosa destruens.*

(2) Highly malignant metastasizing chorio-epithelioma.

(3) Syncytioma.

Inasmuch as our case is of the first, nonmalignant variety, we shall confine our discussion to that group alone.

Grossly, the contents of the uterus vary with many circumstances. When the mole remains in situ, it presents the usual bulky tumor adherent over the implanation site and altered by hemorrhage and suppuration. Hemorrhage, infection and the site of implanation will govern this appearance.

The microscopic appearance is quite specific and in the invasive type the villous structure is less marked and the islands or clusters of Langhans' cells are more numerous. The Langhans' cells in this instance are found in irregular masses instead of being confined to a layer or single row while the syncytial cells are increased in size and number (Figs. 1 and 2).

Among the earlier reported cases which were uncomplicated and which recovered following supracervical hysterectomy is that of Waldo,[22] in 1910. In his description the hemorrhage was stated to have been controlled by a fringe of omentum, and the mole was regarded as a benign growth.

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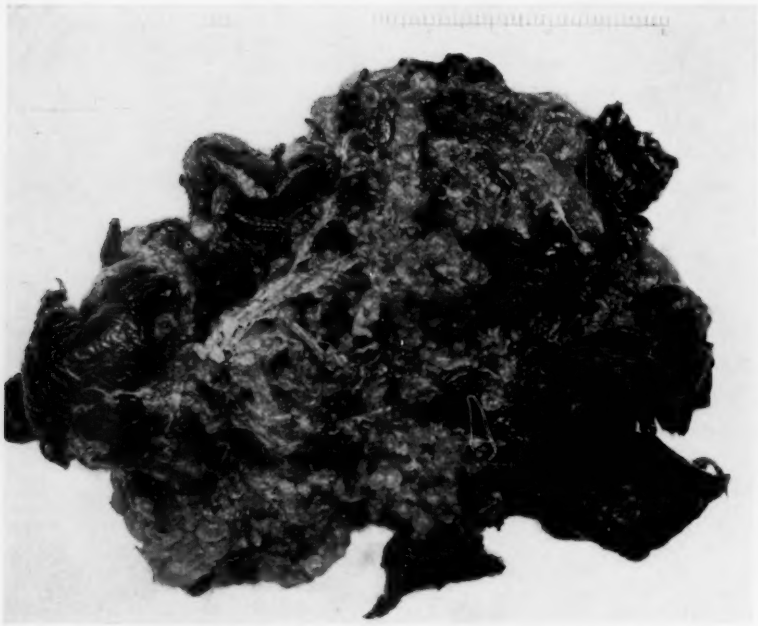

FIG. 1.—Pathologic specimen No. 3416—Extruded Hydatid Mole: Gross examination of the extruded specimen shows it to consist of many masses of thin-walled cysts 2 by 8 Mm. These cysts contain a clear seromucinous material and are arranged in clusters resembling bunches of grapes. A few blood clots are present in addition to the grape-like masses of cystic material. In its retracted form, the entire mass measures approximately 18 by 18 by 18 cm.

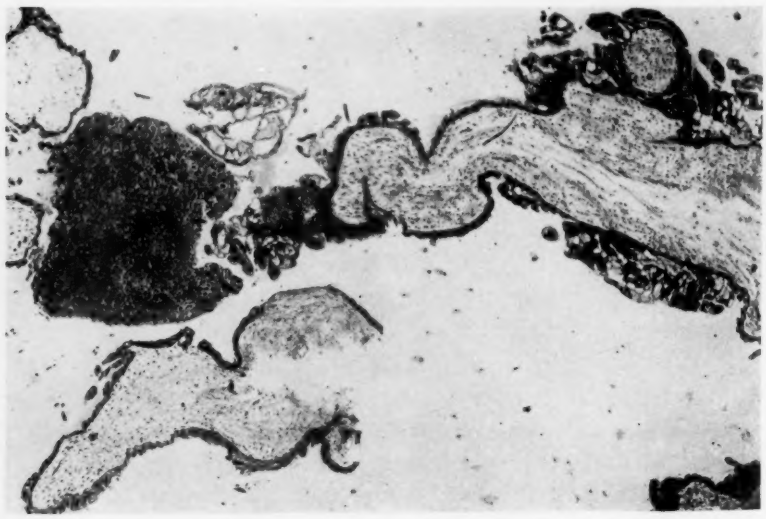

FIG. 2.—Pathologic specimen No. 3416: Photomicrograph of a section of the hydatid mole showing many large chorionic villi. These are composed of an edematous stroma and a hypertrophic Langhans' layer. The layer of syncytial cells is also hypertrophied. The stroma is very edematous and is infiltrated with a few lymphocytes and polymorphonuclear leukocytes. The Langhans' layer in some areas is composed of several islands of heaped-up cells.

Krellenstein,[14] in 1924, reported a case of spontaneous uterine rupture due to hydatid mole, with recovery following supracervical hysterectomy. At the same time he reviewed four other cases: Those of Seitz, in 1904, which resulted fatally; Lord's case, reported in 1868, which also died; and that of Harkness who reported a case, in 1921, that recovered following a hysterectomy, and reviews Waldo's case, of 1910, which also recovered.

Mazet,[16] in 1926, reported a successful result following a hysterectomy, and Johannson,[12] in 1929, details an unsuccessful result with death following operation. Both of these authors stress the difficulty of the preoperative differential diagnosis of perforated uterus due to a hydatid mole from that of ruptured ectopic pregnancy. It is also interesting to note that in the cases of Mazet and Johannson, both patients were multiparae and under 25 years of age. Bland,[2] in 1927, reported a case of perforation of the uterine wall which resulted fatally.

McClure,[18] in 1935, reported a case of spontaneous uterine rupture by hydatidiform mole and emphasizes the rare occurrence of the condition. In his review of the literature he was only able to find seven cases which had been previously reported. The case cited occurred in a patient age 24, who was admitted in shock with the preoperative diagnosis of ruptured ectopic pregnancy. At operation a perforation was found in the left side of the uterus along the course of the uterine artery, and a few vesicles from the hydatid mole were in the process of being extruded into the pelvis through the rent in the wall of the uterus. Panhysterectomy plus a transfusion resulted in complete recovery. The perforation in the thinned-out uterine wall was sufficiently large to admit the index finger. In his case the cervical os was tightly closed—a fact which would rule out criminal abortion. In his report he remarks about the markedly cystic condition of both overies and discusses the frequency of occurrence of this finding in association with the condition of hydatid mole. In two of McClure's cases, which were subjected to celiotomy, marked cystic ovarian changes were noted.

There is no agreement among observers as to the incidence or frequency of this finding. McCallum[17] believes it occurs in a high percentage of cases and Munro and Kerr[19] state that while it is a common finding it is by no means an invariable one. In the appended case report the ovaries presented no cystic changes.

The exact relationship between hydatid mole and the occurrence of lutein cysts in the ovary has not as yet been definitely established but there seems to be some reason to believe that the excess production of hormone by the hyperplastic trophoblastic elements stimulates the development of lutein cysts. Experimental injection of placental suspensions produces marked lutein changes in the ovaries of rabbits. Zondek suggests that lutein cysts are produced by the action of the excessive amounts of gonadotropic hormone on the ovary. These facts would account for the disappearance of the cysts, which sometimes follows successful removal of the mole.[11]

Brews'[3] report, in 1935, on the subject of hydatid mole, was based on

72 cases of this condition and is of particular interest to us chiefly because of Blaikley's[1] discussion of the paper, as he reports an instance of hydatidiform mole, without perforation, but which also had an acute *C. welchii* infection with recovery.

Case Report.—B. B., female, age 51, Italian, was admitted to the Surgical Service, Gouverneur Hospital, January 26, 1937, with the complaint of cramp-like abdominal pain associated with nausea and vomiting for the preceding week, which was not related to the ingestion of food but occurred regularly morning and evening.

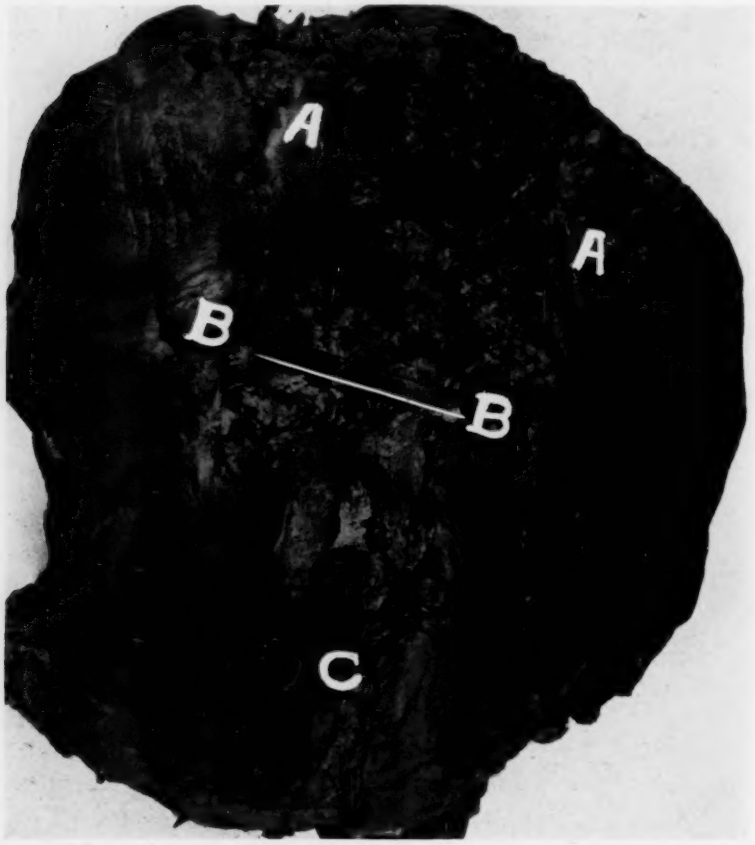

FIG. 3.—Autopsy specimen No. 113: Photograph of the uterus removed at postmortem which has been opened longitudinally to demonstrate the erosion of the fundus of the organ by the destructive hydatidiform mole. Uterus was found to measure 15 cm. from the internal os to the fundus. The perforated area indicated by the points AA′ measures roughly 6 by 8 cm. and indicates how complete was the destruction of the fundus uteri. The wall of the uterus is greatly thinned as one approaches the fundus uteri. The midportion of the organ is held apart at points BB′ by a rule. The cervix is indicated by the point C.

She had had irregular periods of amenorrhea for the past four years. Three days prior to admission she passed a large blood clot per vaginam and bled moderately for the next two days. This episode occurred after a two month period of amenorrhea.

Her past history was irrelevant. Marital history revealed her to have been Para. VII, Grav. V, the last pregnancy having occurred eight years ago (1929).

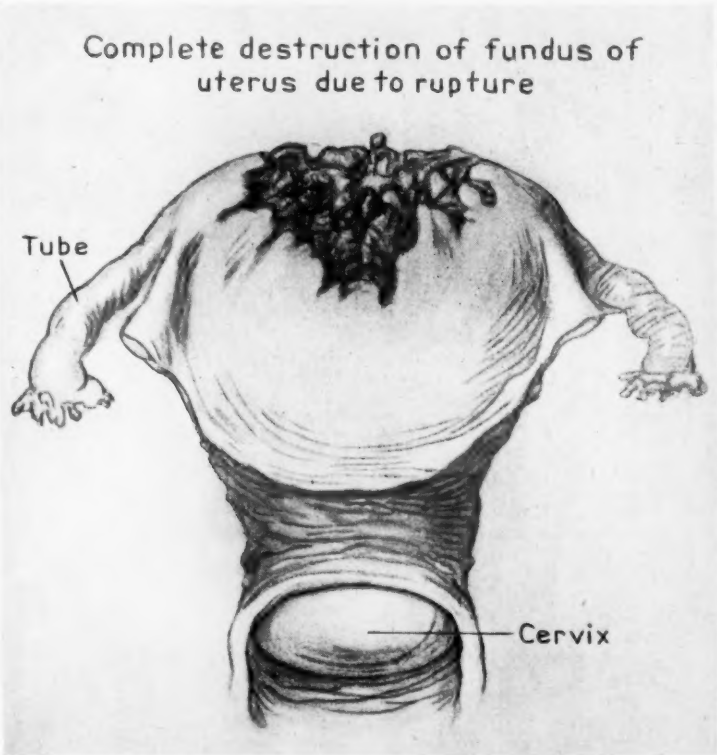

FIG. 4.—A drawing demonstrating the appearance of the uterus as seen at postmortem examination before opening the organ (Fig. 3). The fringe of omentum surrounding the fundus uteri has been removed and the area is shown as it appeared following the perforation due to the destructive hydatidiform mole. The ruptured area measures approximately 6 by 8 cm.

FIG. 5.—Photograph of the ruptured uterus from its superior aspect. This view is taken looking from the fundus towards the internal os and again illustrates the entire destruction of the major portion of the fundus uteri. The points marked AAAAA indicate the outline of the perforated area.

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Physical Examination disclosed a well nourished, white female who appeared acutely ill and complained of abdominal pain. Bimanual pelvic examination revealed an old lacerated, patulous cervix which would admit one finger. There was a large abdominal mass occupying the central portion of the abdomen which extended one finger's breadth above the umbilicus. It appeared to be the uterus, which was freely movable and very tender. No additional masses were palpable in the fornices. There was also present a cyst of the right Bartholin gland about the size of a large lemon.

Diagnosis on Admission.—Fibromyomata with degeneration.

Laboratory Data.—Temperature, 99° F.; pulse, 100; blood pressure, 132/84, blood chem., N.P.N. 24; sugar 95; Wassermann, negative; uranalysis, negative, except for one plus albumin. Aschheim-Zondek test, positive.

On the day following admission, January 27, 1937, the patient's temperature rose to 102.2° F., the pulse remaining between 110 and 120; blood pressure, 90/52. The next day she began to bleed per vagina and passed several small blood clots.

Shortly thereafter a large, flabby mass was extruded from the cervix which resembled a large cluster of grapes. The bleeding became quite profuse and for that reason pituitrin was administered to arrest the uterine hemorrhage. In addition the patient was given morphine and treated for shock. General condition at this time was fair. The diagnosis of hydatidiform mole was obvious from gross examination of the specimen.

Pathologic Examination.—No. 3416. Gross: "Shows the specimen to consist of many masses containing many small thin-walled cysts 2 by 8 Mm. which contain a clear seromucinous fluid. The mass resembles a large cluster of grapes. In addition, a few large blood clots are present" (Fig. 1).

Microscopic Examination.—"Many large chorionic villi are present, composed of an edematous stroma and an hypertrophic Langhans' and syncytial layer. The stroma is very edematous and contains a few red and white blood cells. The Langhans' layer is thickened and in some areas is composed of several layers" (Fig. 2).

Subsequent Course.—On the day following the extrusion of the mole, the patient was taken to the operating room and examined under anesthesia. The uterus was still greatly enlarged, with the fundus at the level of the umbilicus. Two small pieces of tissue were removed from the cervical canal but no curettage was performed.

The following morning, January 30, 1937, her temperature was 103° F.; pulse, 120; and her general condition reported as poor. At this time a beginning jaundice was noted. Blood pressure, 90/56; icteric index, 21; white blood cells, 20,000; polymorphonuclears, 90 per cent. She was given three transfusions of 350 cc. each and in spite of these supportive measures the patient expired on the sixth day after admission to the hospital.

Repeated blood cultures were reported as negative.

Autopsy.—A postmortem examination was performed and the entire fundus of the uterus was found to have been the site of a necrotic process and to have been eroded by the destructive hydatidiform mole. The protocol states: "The uterus is found to be soft, large, friable and boggy. The omentum is found to be adherent to the uterine fundus. From the internal os to the fundus measures 15 cm. From cornu to cornu, the viscus measures 10 cm. The fundus, for an area 6 by 8 cm., is necrotic, hemorrhagic and diffusely ruptured (Figs. 3, 4 and 5). A fibrinopurulent peritonitis is also present.

Microscopic Examination of sections of the liver show formation of gas bubbles in the parenchyma of the organ (Section No. 113) and colonies of gram-negative *C. welchii.*

Pathologic Diagnosis.—(1) Perforation of uterus due to destructive hydatidiform mole; (2) *C. welchii* sepsis; (3) acute generalized fibrinopurulent peritonitis.

SUMMARY

(1) It is exceedingly rare that an apparently benign mole assumes invasive propensity and causes a spontaneous uterine rupture; up to 1935 only seven cases were found by McClure in the literature.

(2) In those cases which were operated upon and recovered, the preoperative diagnosis was almost always confounded with ectopic pregnancy.

(3) There is no agreement among observers as to the frequency of cystic ovarian changes associated with the condition of hydatidiform mole. In the case herewith reported, the ovaries were entirely normal.

(4) In our case, the entire fundus of the uterus was destroyed by the massive rupture due to the invasion of hydatidiform mole.

(5) One other case of hydatidiform mole associated with *C. welchii* sepsis is reported in the literature, with recovery. In that instance, however, there was no complicating uterine rupture.

BIBLIOGRAPHY

[1] Blaikley, J. B.: A Follow-up Survey of the Cases of Hydatid Mole and Chorio-epithelioma from London Hospital Report. Proc. Royal. Soc. Med., **28,** 1228, 1935.

[2] Bland, P. Brooke: Hydatidiform Mole Complicated by Perforation of the Uterine Wall and Secondary Chorio-epithelioma of the Pelvis. Am. Jour. Obstet. and Gynec., **13,** 189, 1927.

[3] Brews, A.: A Follow-up Survey of the Cases of Hydatid Mole and Chorio-epithelioma. London Hospital, Proc. Royal Soc. Med., **28,** 1213–1228, 1935.

[4] Brouha, M., and Kridelka, L.: Hydatidiform Mole; with Special Reference to Diagnosis. Bruxelles Med., **16,** 648–652, February, 1936.

[5] Curtis, Qui: Contribution a l'etude de la mole dissequante ou penetrante. Ann. de Gynec., **10,** 321, 1913.

[6] Daleas, P.: Rare Accidents in Molar Pregnancy. Bull. Soc. d'obstet. et de Gynec, **25,** 186–189, 1936.

[7] Devraigne, L.: Mole Hydatidiforme et ses Complications. Semaine d'hop. de Paris, **11,** 1–11, January, 1935.

[8] Ewing, J.: Neoplastic Diseases. W. B. Saunders, Philadelphia, 608–624, 1928.

[9] Garber, M., and Young, A. M.: Early Chorio-epithelioma Arising in Hydatid Mole. Am. Jour. Obstet. and Gynec., **32,** 321–327, August, 1936.

[10] Gizowski, T.: Spontaneous Uterine Perforation by Malignant Hydatidiform Mole. Ginek-polska, **13,** 380–385, April–June, 1934.

[11] Illingworth, C. F. W., and Dick, B. W.: Textbook of Surgical Pathology, 650, 1932.

[12] Johannson, J.: Mola hydatidosa destruens. Acta obstet. et Gynec. Scandinav., **8,** 131, 1929.

[13] Koehler, R.: Aschheim-Zondek Reaction in Hydatid Mole; the Diagnostic and Prognostic Significance. Zentralbl. f. Gynak., **59,** 1049–1053, 1935.

[14] Krellenstein, J. B.: Hydatid Mole with Spontaneous Rupture of the Uterus. Am. Jour. Obstet. and Gynec., **8,** 636, 1924.

[15] Lima, D. F., and Marengo, R.: Complications of Hydatidiform Mole; Report of 3 Cases. Prensa med. argent., **22,** 18–31, March, 1935.

[16] Mazet, M.: Perforation uterine par Mole Hydatidiforme. Lyon Med., **137,** 336, 1926.

[17] McCallum, W. G.: Textbook of Pathology, 1087, 1928.

[18] McClure, H. I.: Hydatidiform Mole. Spontaneous Perforation of Uterus. Jour. Brit. Emp., Obstet. and Gynæcol., **42,** 663–667, 1935.

[19] Munro, Kerr, *et al.*: Textbook of Obstetrics and Gynecology, 208, 1933.

[20] Sherman, J. T.: Hydatid Mole—A Study of 78 Patients. Am. Jour. Surg., **27,** 237–244, February, 1935.

[21] Sturgis, M. C.: End-Results in 10 Cases of Hydatidiform Mole by Curettage. Am. Jour. Obstet. and Gynec., **19,** 641, 1930.

[22] Waldo: Spontaneous Uterine Rupture Due to Hydatidiform Mole. Am. Jour. Obstet., **26,** 863, 1910.

THE CAUSE OF THE PUTRID ODOR OF PERFORATED APPENDICITIS WITH PERITONITIS

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THIS paper is presented to correct a prevalent but erroneous impression that *B. coli* is responsible for the putrid ordor of the pus in perforated appendictis. The numerous references to "*B. coli* odor" that can be found in the literature and the uniform impression among the staff members, both senior and resident, of this clinic that *B. coli* causes this characteristic odor, lead us to assume that this belief is generally held. We have been unable to trace the origin of this idea.

During the past two years the pus obtained at operation in 100 cases of acute perforated appendicitis with abscess formation or peritonitis has been cultured both aerobically and anaerobically at this clinic. The results of this bacteriologic study are to be found in the ANNALS OF SURGERY, 107, 517–528, April, 1938. In working with the bacteria isolated from these cases, the uniform fetid odor of anaerobic cultures, and likewise the consistent absence of this odor in the aerobic cultures, was noticed. This observation led to our investigation of the rôle played by *B. coli* in the production of the "*B. coli* odor" in instances of perforated appendicitis.

It was elected to use sterile human pus as a culture medium in this experiment in an effort to approach as closely as possible the conditions found *in vivo*. We have been uniformly unsuccessful in attempting to produce peritonitis in rabbits with pure cultures of *B. coli*. This pus was obtained from two different sources: (1) A tuberculous pleural empyema; and (2) a pyarthrosis of a shoulder joint.

Twelve tubes each containing 8 cc. of tuberculous empyema pus were inoculated in the following manner: (1) Four tubes were used as controls, two being incubated aerobically and two anaerobically.

(2) Four tubes were inoculated with *B. coli*, three of which were incubated aerobically and one anaerobically.

(3) Four tubes were inoculated with anaerobic *Streptococcus putrificus* and anaerobic *B. melanogenicum*,[1] all of which were cultivated under anaerobic conditions. These two organisms were chosen from the numerous types of anaerobic bacteria composing the bacterial flora of appendicitis peritonitis because of their greater prevalence. The former was present in our series in 66 per cent of the cases, and the latter in 93 per cent. In addition, these two organisms were usually found growing in symbiosis and were extremely difficult to separate. All 12 tubes were incubated for four days at 37° C., and then examined for growth of organisms and production of odor. The control tubes were all negative for growth of organisms and production of odor. All tubes which had been inoculated with *B. coli* showed good growth of this bacteria but gave no evidence of a putrid odor. On the other hand,

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in all the tubes of the third group a heavy growth of the anaerobic bacteria had occurred, and these tubes gave off the marked, penetrating, putrid odor characteristic of the pus in cases of perforated appendicitis. This experiment was repeated, using the sterile pus obtained from the case of pyarthrosis, and the same results were obtained.

From the above experiments it is evident that the *B. coli* is in no way responsible for the production of the putrid, so-called "*B. coli* odor."

Further proof is to be had in the fact that the typical "*B. coli* odor" was found in 12 cases of appendicitis peritonitis from which *B. coli* was not isolated.

It has been impossible for us to produce a fatal peritonitis in guinea pigs or rabbits with intraperitoneal injections of the *B. coli.* The peritoneal fluid of these animals three and five days after injection of the *B. coli* has no putrid odor. Inoculation of mixed peritonitis cultures without *B. coli* produces a fatal peritonitis in rabbits, the exudate having the characteristic putrid odor.

We are unable to explain the origin and prevalence of this erroneous conception of the ability of the colin bacillus to produce putrid products during their growth in pus. The ability of anaerobes to produce foul odors, however, is recognized especially among German authors. Fraenkel[2] has stated that the putrid odor of pus in any given lesion bespeaks the anaerobic nature of its infecting agent. This has also been our experience.

Heyde[3] (1911) published a careful study of the anaerobic flora of appendicitis, concluding that *B. coli* played a subordinate etiologic rôle. He did not believe this Bacterium had the ability to form putrid products within the animal body. This opinion has apparently been generally overlooked or disregarded.

Brütt[4] (1923) found the anaerobic Streptococcus in 45 cases out of a total of 107, emphasized the putrid nature of the pus produced by the anaerobic Streptococcus, and made the observation that the odorless seropurulent pus was probably due to *B. coli* alone. Based upon his personal experience, the ability of *B. coli* alone to produce pus having the characteristic foul odor so frequently encountered in appendicitis was doubtful. He believed that this fetid odor was the result of infection by the colon Bacillus in association with the anaerobic Streptococcus.

In addition to the more frequently encountered anaerobic *Streptococcus putrificus* and the *B. melanogenicum*, other anaerobic organisms capable of producing putrid odors during their growth were recovered by us from the pus of appendicitis peritonitis. These organisms included members of the Clostridium group, the *Streptobacterium fetidus*, and other forms of gram-positive and gram-negative unidentified Bacilli.

CONCLUSIONS

(1) *B. coli* are not responsible for the putrid odor present in cases of perforated appendicitis peritonitis, generally designated as "*B. coli* odor."

(2) When inoculated into sterile pus and incubated, *B. coli* exhibits no ability to form putrid products.

(3) The characteristic putrid odor of appendicitis pus is caused by the presence and growth of anaerobic bacteria, chiefly the *B. melanogenicum* and anaerobic Streptococci.

REFERENCES

[1] Oliver, W. W., and Wherry, W. B.: Jour. Infect. Dis., **28**, 341, 1921.
[2] Fraenkel, Eugene: Arch. f. Path. Anat., **254**, 639–655, 1924.
[3] Heyde, M.: Beitr. z. klin. Chir., **76**, 1, 1911.
[4] Brütt, H.: Beitr. z. klin. Chir., **129**, 175–185, 1923.

A POINT IN THE CLINICAL DIAGNOSIS OF URETERAL CALCULUS

A PRELIMINARY REPORT

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SOME years ago the writer made the observation that in certain cases of calculus in the lower third of the ureter, that is, below the brim of the bony pelvis, there was one point in the abdomen where tenderness was more marked than elsewhere. After further observation it was found that this point, whether on the right or on the left side, was located just below the one described by McBurney[1] as being the site of maximum tenderness in acute appendicitis. McBurney described this point in the adult as "one and a half to two inches inside of the . . . anterior superior spinous process of the ilium on a line drawn to the umbilicus." He also stated that it was "not enough to compress with the whole hand the region of the iliac fossa" but that pressure must be made with the finger-tip "to determine that the most sensitive point is a definite one in most cases."

A similar point of maximum tenderness will be described, which may be elicited by employing the same procedure. It can be found with great accuracy by first locating McBurney's point. One then moves the finger-tip downward and inward one inch from this point and in a direction at right-angles to the line on which McBurney's point lies (Fig. 1). By pressure with the finger-tip the patient will show evidences of very definite pain, sometimes even with only moderate digital pressure. There is generally no spasm unless deep and vigorous pressure is made. As in McBurney's observation, it is not enough to press with the entire hand over this area, as while there may be more or less tenderness, there may be none at all. In no instance has there been any evidence that hyperesthesia of the skin is a factor. Having located this point, on one side or the other, concentric circles can be drawn around it as shown in the diagram. In a typical and well marked case, finger-tip pressure around the most distant circle may elicit no tenderness; as the finger moves from one circle to the other, toward the center, tenderness becomes more and more marked, until its maximum is found to be at the point indicated.

The phenomenon has now been sought for in 115 cases of proved ureteral calculus. Positive findings were obtained in 47 instances, or 40.8 per cent,

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occurring both on the left and on the right side, and about equally divided between men and women. In probably a majority of these cases the ureter was no more than slightly or moderately dilated, nor was infection present in any great severity in more than a few cases. It has not seemed to make any difference in the findings whether the stones were single or multiple, large or small, or whether they lay just outside of the bladder or just below the bifurcation of the iliac vessels. In a few instances it has been found that after the removal of the stone, either by spontaneous passage or by operation, the tender spot could no longer be demonstrated. McBurney stated that in acute

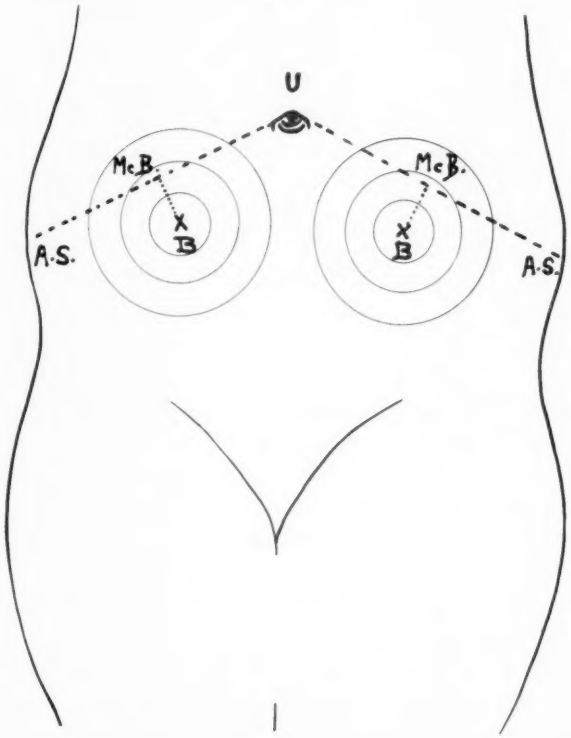

FIG. 1.—Diagram of point of maximum tenderness in stone in lower ureter. U—Umbilicus. A.S.—Ant. Sup. Spine. McB.—McBurney's Point. B—Point of maximum tenderness. This point lies downward and inward one inch below McBurney's point and at right angles to it. It is found in over 40 per cent of cases. Tenderness increases around concentric circles to point B.

appendicitis "from the first hours of the disease even up to the end of several days, this sign may be clearly made out in every case." The writer acknowledges that he has no evidence as to how long this tenderness may persist in the presence of a stone, nor does he claim that it is present in "every case." The observation is described in the belief that it may, in certain cases, help to clear up an obscure diagnosis. It is known that about 4 or 5 per cent of stones in the lower third of the ureter cannot be roentgenographically demonstrated, either because the stone is composed of uric acid, or because it has the same density as the sacrum against which it lies. In these cases the diag-

nosis would doubtless eventually be made by cystoscopic study and perhaps, especially, by the passage of a wax-tipped catheter.

A case related to me personally by Dr. Edward L. Young, Jr., illustrates some of the observations made in this communication. The patient, a male, age 40, without previous urinary or abdominal symptoms, was seized with sudden, severe pain in the right lower quadrant. There were no urinary symptoms, but there was nausea. Temperature, 99.2° F.; white blood count, 23,000. Urine sediment showed an occasional white cell, no reds. Marked tenderness, but no spasm (until deep pressure was made), was found on the right side at the point which has been described. There was no costovertebral tenderness. In the belief that this was a case of acute appendicitis preparations were made for operation. During this time, and on the chance that there might be an ureteral calculus present, cystoscopy was performed. A small stone was seen protruding from the right ureteral orifice. It was removed by rongeur forceps. The pain disappeared almost at once and the tenderness had subsided by the time the patient was returned to his bed. There were no further symptoms.

When it comes to an explanation of this point of tenderness, the writer finds himself somewhat at a loss. Certain observations made on the ureter at various times, while of interest, do not seem to throw much light on the question. Some years ago the writer saw an elderly lady who had had both ureters brought out on her back just below the costovertebral angles. About two inches of normal-looking ureter protruded beyond the skin on either side. The ends of these ureters could be snipped with scissors or crushed with a clamp without causing any sensation to the patient. Nor did she realize it when a crochet needle was inserted into the ureter and moved vigorously up and down in its lumen, producing considerable bleeding by trauma of the hook. When, however, a small clamp was inserted into the ureter and then opened, thereby dilating its lumen, quite severe renal colic was produced, which subsided promptly, however, when the tension was released. From these observations it may be deduced that renal or ureteral colic is produced, not by the roughness of a stone but by the dilatation of the ureter or renal pelvis which it causes.

More recently, and inspired by the work of Dr. Chester M. Jones, I have tried the effect of dilatation of the intact ureter. A Dourmashkin catheter was passed up the ureter, first on one side and then on the other, in three female patients. In two, both ureters were normal, in one there was considerable dilatation on one side but none on the other. The bag surrounding the tip of the catheter was dilated to what appeared to be its maximum extent (using about 2 cc. of 12 per cent sodium iodide solution) when the catheter was in the ureter at 25, 20, 15, 10 and 5 cm. A series of roentgenograms, in one of these patients, showed that the bag was dilated laterally and that it had not been merely elongated in the lumen of the ureter. Two of the women had no pain or tenderness at any time, or in any place, when the bag was dilated. The third patient experienced a little momentary pain in her

normal left ureter when the bag was dilated at about 10 cm., but there was no tenderness. This experiment with the ureter has, therefore, failed so far in producing the pain and tenderness which Jones has been able to elicit by the inflation of a bag at various points in the gastro-intestinal tract.

Aid in the solution of this problem has been sought at autopsy. In two bodies, long, sharp, and rather heavy steel pins were driven through the abdominal wall on either side at the point under discussion, until they were fast in the bone. The abdomen was then opened, care being taken not to dislodge the pins. On exposing the ureters by retroperitoneal dissection, and without disturbing their position, they were found in both instances to lie almost an inch to the medial side of the pins. It would seem, therefore, as if pressure with the finger-tip did not compress either the ureter or the stone lying within it. It undoubtedly does impinge upon both layers of the peritoneum, upon the coils of intestine lying beneath and upon the muscles of the abdominal wall and of the pelvis. That none of these structures is the seat of pain is obvious from the fact that in the absence of stones, and even in the presence of 60 per cent of stones, the phenomenon is not elicited.

The work of various investigators has shown that the ureter is very richly supplied, and in a most intricate manner, by the sympathetic nervous system. Wharton[2] has shown that the ureter is supplied by nerves from the lowest renal ganglion at the head of the spermatic and ovarian plexuses and from the aortic, hypogastric and pelvic plexuses. Not only this but it is in close contact with "the rich network of fine nerves which course through and directly beneath the peritoneum." Wharton has shown: (1) That these nerves can be divided without interfering with ureteral function; and (2) that clinically, the patient is relieved of the ureteral colic. This is "rather strong evidence," Wharton says, "that at least one of the functions of these nerves is to convey sensations of pain—in other words that they contain afferent or sensory fibres." It is probable that further observations following the same lines as those resulting from the painstaking research by Wharton will throw light on the problem which has been presented.

In the present state of our knowledge this work does not make clear *why* the point of tenderness under discussion is situated *where* it is, or why it is not present in all cases. Neither does it explain why if it is absent at this point which has been described, it is not likely to be present elsewhere. Possibly these variations indicate that the location or arrangement of the ureteral sympathetic nerve supply varies with different individuals, thus accounting for the discrepancies observed.

Further observations, both clinical and experimental, may help to elucidate the question. There is no doubt that any procedure, or observation, which will help toward the solution of a difficult and obscure diagnosis is worth while.

REFERENCES

[1] McBurney, Charles: Annals of Surgery, **13**, 233–254, 1891.
[2] Wharton, Lawrence, R.: Jour. Urol., **28**, No. 6, 639–673, December, 1932.

BOOK REVIEW

CHEMISTRY OF THE BRAIN by Irvine H. Page, M.D.
Charles C. Thomas Co., 1937.

This timely review is distinguished by a clear discussion of complex chemical problems of the brain and an excellent selection of subject matter. While emphasis is laid particularly on the chemistry of the lipids, there is adequate consideration of the rôle played by carbohydrates, proteins, and electrolytes. The chapters on gaseous metabolism, enzymes, and vitamins succeed in assembling all the important facts which are widely scattered in the literature. The discussion of oxidations in the brain by J. H. Quastel is of special value.

One phase of this book which should be particularly interesting to clinicians is the manner in which the facts of brain chemistry are correlated to clinical conditions. Another important feature is the liberal cross references to current literature in each chapter which offers a comprehensive bibliography for anyone undertaking work in this field. In addition to covering the field of brain chemistry in a very creditable manner the material is presented in a way that makes for interesting and stimulating reading. This book is a distinct contribution.

JOSEPH HUGHES, M.D.

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